

ESSAYS ON EXPORTING AND FIRM PERFORMANCE IN CHINA

by

MIN ZHU

M.Soc.Sci

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Chapter 1

Introduction

1.1 Introduction

This dissertation consists of three self-contained essays and covers both theoretical and empirical topics related to the behavior and performance of firms participating in international trade in a large emerging economy, i.e., China. It aims to resolve two themes: how a country's export promotion policies affect firms' productivity and its welfare, and how firms adjust their export behavior to changes in trade policies. These questions are essential because firms do not operate in a vacuum and trade policies evolve. I begin with a theoretical model of how the interaction between trade barriers and the large scale of processing trade¹ shapes the export patterns of Chinese firms in Chapter 1. I then discuss the evidence on the effects of trade policy changes on the export behavior of Chinese firms in Chapters 2 and 3. The first essay extends the Melitz (2003) heterogeneous-firm model. Chapter 2 exploits the US antidumping measures against China as an exogenous shock to firms and uses a difference-in-difference strategy, whereas Chapter 3 uses alternative dependent variables to broaden the results. In what follows, I outline the results and highlight the contributions of the three essays respectively.

The first essay focuses on firms that solely export, i.e., processing exporters in China. One-third of Chinese firms are processing exporters, which almost exclusively produce for foreign countries and sell more than 70 percent of their output abroad. Nevertheless, recent empirical research using the longitudinal firm-level data from China has substantiated that processing exporters are the least productive firms (e.g. Dai et al., 2016; Lu, 2010). Some of these studies have further shown that processing exporters earn lower profits, pay less wages, are relatively smaller in terms of sales, have lower capital intensity, and are less skill intensive (e.g. Fernandes and Tang, 2015). These factors run counter to the accumulated knowledge about exporting firms in de-

¹Processing trade refers to the activity of assembling tariff exempted imported inputs into final goods for resale in the foreign markets (Dai et al., 2016).

veloped countries: exporters tend to be larger, pay higher wages and be associated with superior productivity relative to their non-exporting counterparts.

In order to reconcile these contrasting findings, I propose an extension of Melitz (2003) two-country general equilibrium model which distinguishes between processing exporters, non-exporters, and regular exporters. I also introduce fixed domestic trade costs, which capture the salient feature of Chinese domestic market is segmented by provincial borders and access to other regional markets requires fixed entry costs.² The model shows that the presence of domestic trade costs alongside the processing trade leads firms self-selecting to become processing exporters, non-exporters, and regular exporters. It then shows that falling trade costs deliver welfare gains in China, albeit the impact of freer trade is unevenly distributed across different types of firms. More importantly, the paper highlights that the reductions in domestic trade barriers have the most pronounced effects: which expand the set of available goods to domestic (Chinese) consumers and hence raise the aggregate welfare.

The focus of the second essay lies in how temporary increases in export costs in one market affect firm export behavior across markets. In particular, I investigate how Chinese exporters respond to market-specific tariff shocks that arise from US antidumping measures both to the US and to other countries. Antidumping measures mainly take the form of an ad-valorem tariff. While studies in this area are mostly concentrated on the protected firms (e.g. Pierce, 2011; Konings and Vandenbussche, 2008), this paper aims to contribute to the relatively sparse literature by exploring the effects of antidumping measures on the adjustment across products within targeted exporters.

Using Chinese customs data between 2000 and 2006, I first assess the trade destruction effect at the product level. I find that antidumping measures severely distort bilateral trade flows between China and the US. In addition, there is a significant adverse effect on the extensive margin. That is, antidumping measures lead product less likely to be exported to the US and there is a sharp decrease in the number of exporters serving the US market. I then estimate the impact of US antidumping measures on Chinese exports in non-US markets, which has been overlooked by literature. Surprisingly, I do not find any evidence that the US imposition of such trade restrictions has any impact on Chinese exports in alternative markets. That is, trade restriction in one market does not affect the evolution of aggregate export in another market, where the policy has not changed. This result hence questions the justification of the Chinese overcapacity would undermine and distort well-established world trade patterns.

²The types of domestic trade barriers include physical barriers, outright prohibition through administrative decree, financial benefits for firms selling local goods, local purchasing quotas, poor infrastructure and business conditions, less efficient government (Wong, 2012; Pflüger and Russek, 2013).

To gain a better understanding of the mechanisms driving the effects at the product level, I sharpen my analysis by studying the adjustment channels at the firm-product-destination level. I first document that Chinese firms that were hit with US antidumping measures are less likely to export the targeted products and restrict their export flows to the US market. More importantly, these surviving firms also decrease the export to alternative markets but charge higher prices.

I next study whether an antidumping duty against one product within a firm influences its export decisions for other products across markets. I find that firms exposed to the US trade restrictions reduce their export flow of other products in the US market. That is, an increase in export costs in one market leads firms to downsize their all their export in that market, possibly due to economies of scale. I also find that the imposition of such measures, as an indicator of rising trade policy uncertainty, induces firms less likely to export the unaffected products in other markets. One implication derived from this result is that antidumping measures generate deterrent effects that spread to other products in other markets, widening our understanding about the breadth and extent of such measures. In this regards, this paper contributes to the literature by documenting that the within-firm changes constitute a significant channel of firms' adjustment to antidumping shocks, which has been largely neglected by existing literature.

In the third essay, I investigate how Chinese multi-product firms adjust their export scale and product scope in response to US antidumping measures utilizing a difference-in-difference design. This essay differs from the second one by focusing on the firm-level adjustments along the extensive margin of product adding and dropping, as well as along the intensive margin of changes in sales level and concentration among surviving products. Existing literature has well documented that antidumping measures significantly reduce export volumes from named countries, 50%-60% on average (e.g. Prusa, 2001; Bown and Crowley, 2007; Carter and Gunning-Trant, 2010). However, it has dedicated too little attention to the relationship between product churning with firms and antidumping measures. This is an important omission since such measures may lead firms to drop the targeted products and/or add other unaffected products. This essay therefore aims to fill this gap.

Specifically, I compare the export decisions (e.g. how much to export, the number of exported varieties, *et cetera*) for firms that were subject to the US anti-dumping duties (*punished* firms), to firms that were investigated but did not face any duties (*investigated* firms). I find that firms that were exposed to the US trade restrictions reduce their export flows by 7.5 percent. Decomposing the firm level exports into the extensive and intensive margins, I document that firms react to such rises in trade costs via narrowing the portfolio of exported products (*intra-firm* extensive margin).

However, there is no impact on the average sales per product within a firm, i.e., the extensive margin dominates. I also find that multi-product firms tend to further skew their sales toward their best-performing products.

I then evaluate how product flows, measured by the counts of varieties added and dropped within firms, are affected by antidumping measures. I find that the *punished* firms experience a more intense process of both the introduction and discontinuation of products, relative to the *investigated* ones. In particular, they shed more products than they add, emphasizing the role of “creative destruction” in firms’ adjustment to changes in trade policies. My analysis therefore highlights the role of selection across products within firms matters for transmission of external shocks.

Antidumping measures have become one of the most intensively used forms of trade restrictions in recent years. Despite the growing importance, there is little understanding of their effects at the micro level. My study of the impact of antidumping measures at the firm level and at the firm-product-destination level is helpful to understand the observed product level responses because they are combinations of the micro-economic responses. These findings are also informative to policymakers, as they are crucial for designing appropriate policy interventions. Understanding the mechanisms and the channels through which these measures affect the allocation of resources within firms constitute the first step in understanding how exporters react to such negative trade shocks.

Overall, the dissertation analyzes different aspects of the increased participation of Chinese firms in international market. It highlights the interdependence of today’s integrated world economy and trade policies affecting two of the largest economies in the world deliver repercussions for third countries.

The essays presented in this dissertation naturally leave room for further investigations. The first essay suggests that trade-induced reallocation effect which generates aggregate productivity growth does not work effectively in China, because processing trade is pervasive and with the presence of domestic trade barriers. It will be important for future research to measure Chinese domestic trade barriers and quantify the responsiveness of trade flows to fixed barriers. Likewise, the second essay suggests that the use of antidumping measure on one set of products from a given firm creates negative spillovers to other unaffected products from the same firm. This finding opens up exciting avenues for future research. It would be intriguing, for instance, to comprehend the role of global supply chain in the determining trade policies. Finally, the last essay describes how Chinese firms adjust their product scope in response to US antidumping measures. It would be particularly interesting to explore these patterns more thoroughly, i.e., what types of products firms tend to add and drop. This exercise will inform whether and how antidumping measures impact firms’ decisions on product

quality. Understanding the implications of antidumping measures on product quality is essential because it enables us to comprehend to what extent the exporting firms and thereby the exporting economy can reduce the impact of antidumping measures by reallocating their production and exports to higher quality (and by implication, higher markup) products.

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Chapter 2

Processing Trade, Firm Heterogeneity and Export Behavior of Chinese Firms

Abstract

This paper incorporates processing exporters into an asymmetric two-country general equilibrium model by Melitz (2003) to explain trade performance and export patterns in China. The model shows how the presence of domestic trade costs alongside the processing trade divide firms into processing exporters, non-exporters, and regular exporters. It then shows that falling export costs deliver welfare gains in China, albeit the impact of freer trade is unevenly distributed across different types of firms. More importantly, the paper highlights the reductions in domestic trade barriers have the most pronounced effects, which expand the set of available goods to Chinese consumers and hence raise the aggregate welfare.

2.1 Introduction

The increasing integration of the Chinese manufacturing into the world economy has led China's extraordinary trade performance over the last three decades. This spectacular achievement is mainly attributable to the international processing: the activity of assembling tariff-exempted imported inputs into final goods for resale in the foreign markets (Dai et al., 2016). As a means of export promotion, processing trade has been implemented in China for over thirty years and has successfully boosted its export. It accounts for nearly half of China's exports and 40 percent of imports in the 2000s. Additionally, the sheer magnitude of processing trade in China has generated a vast number of firms that almost exclusively produce for foreign countries. I refer to these firms as processing exporters. Defever and Riaño (2017) report that more than a third of Chinese exporters sold 70 percent or more of their output abroad between 2000

and 2006.¹ Processing trade is also gaining popularity in other developing countries. In 2006, processing enterprises from 130 countries employed an estimated 66 million people, accounting for the majority of exports from countries like China, Mexico, Vietnam, and recently sub-Saharan African nations (International Labor Organization). Motivated by past success, the Chinese government still considers processing trade as a fast and efficient path to industrialization and has used various export policies to encourage it to date.

Despite the importance of processing trade for China, research toward processing exporters is scant. Previous studies have accumulated a rich stock of knowledge about exporters in developed countries: they tend to be larger, pay higher wages, sell more in the domestic market and are associated with superior productivity than their non-exporting counterparts (e.g. Bernard and Jensen 1999; Aw et al. 2003; Bernard et al. 2003). However, recent empirical research using the longitudinal firm-level data from China has substantiated that processing exporters are the least productive firms (e.g. Lu 2010; Dai et al. 2016). Other studies have highlighted that processing exporters are concentrated in labor-intensive sectors and are mainly invested by Foreign-invested Enterprises (FIEs) (e.g. Fu 2011; Lemoine 2010; Fernandes and Tang 2015). The presence of processing exporters distinguishes China from the developed countries. There are no so-called processing exporters in the US or France. The goal of this paper is therefore to incorporate the relevance of processing exporters into the heterogeneous-firm model to strengthen its explanatory power for China that relies heavily on processing trade.

To do so, I propose an extension of Melitz (2003) general equilibrium model into an asymmetric two-country setting. Heterogeneous Chinese firms may choose to operate in either processing trade or regular production regimes, based on their idiosyncratic productivity. However, firms in the foreign country (e.g. the US) can only pursue regular production mode. This asymmetric assumption matches the fact that processing trade is only implemented in China. I also introduce fixed domestic trade costs, which could induce firms to export but not to serve the domestic market. These two assumptions capture the salient features of processing trade in China. To operate in processing trade, firms must fully withdraw from the domestic market and sell all of their output in the foreign markets. In other words, processing exporters are not allowed to access the domestic market, and hence there are no domestic trade costs associated with them. Furthermore, because processing exporters passively receive orders from foreign buyers, and therefore they have negligible fixed export costs.

The model shows that the presence of domestic trade costs along with the processing trade leads firms self-selecting to become processing exporters, non-exporters,

¹Gao and Tvede (2017) also find that the average share of processing exporters out of all exporters in China is 27 percent.

and regular exporters. In particular, regular exporters with both domestic and foreign markets have the highest productivity, followed by non-exporters, and finally by processing exporters. This model also shows that a reduction in fixed export costs induces better-performing regular exporters to benefit from globalization through expanding market; while worse-performing non-exporters suffer from globalization through contracting market. The least productive processing exporters are forced to exit, and there is a revenue loss for the surviving ones. Overall, each of these responses reallocates resources toward more productive firms and hence generates improvement in aggregate productivity levels.

Trade liberalization in variable trade costs delivers similar effects to the falling export costs. High-productive regular exporters experience the increased revenue through greater foreign sales. The most efficient non-exporters are able to overcome the costs of entering the foreign market, and thereby induce the entry of new regular exporters into the export market. Moreover, the falling variable trade costs generate the entry of new firms engaging in processing trade and hence promote processing trade activities in China.

The analysis related to fixed domestic trade barriers shows that productivity constrained firms, and presumably the segmented domestic market as a whole, lead firms to get stuck in low value-added stages of supply chain and are unable to pursue more profitable opportunities. Integrating the Chinese domestic market might be thus an important prerequisite for firms moving into higher value-added, more profitable activities. Moreover, reducing the domestic trade protectionism would expand the total varieties for consumption, and thus increase aggregate welfare. That is, the most productive processing exporters would find it profitable to enter the domestic market as domestic trade costs fall, and thereby create the entry of new firms into the domestic market, which, in turn, expanding in the range of product varieties available to Chinese consumers. Also, as low efficient processing exporters exit and high efficient ones pursue regular production mode, the mass of firms engaging in processing trade declines. This particularly benefits China, which could potentially reduce its heavy reliance on processing trade for growth. As pointed by Wong (2012), the domestic trade is almost as twice as large as international trade in the Chinese economy; it could overtake international trade as a more important driver of China's growth if the decline in domestic barriers were to accelerate. Therefore, a unified national market could boost the domestic demand and keep the Chinese economy expanding while overseas markets remain weak.

The model can also be used to evaluate the welfare consequences of increased exposure to trade in the presence of large scale of processing trade. Trade liberalization and domestic market integration lead to welfare gains. However, the welfare improve-

ment generated by a reduction in variable trade costs is counteracted by the distortion stemming from the expanded number of processing exporters operating in China. The accession to WTO in 2001 triggered a sharp rise in the number of firms engaging in processing trade, which have become the major component in China's export and the essential vehicle of its trade surge in the 2000s. To this end, the model is well-suited to explain the observed empirical pattern that falling variable export costs are related to the increasing number of processing exporters in China.

More broadly, this analysis advances to the following strands of literature. It speaks to the emerging research on export-platform foreign direct investment (FDI), i.e., on multinational enterprises (MNEs) that process their final goods in developing countries (Helpman et al., 2004; Yeaple, 2009). The contribution is the model offers a better understanding of how and why firms operate at different stages along the value-added chain. There has also been increased interest in the costs and benefits resulting from China's processing trade as well as to the large body of research investigating the welfare implication of export processing zones and duty drawbacks (Fu, 2011; Ma et al., 2009; Fernandes and Tang, 2015; Manova, 2012). Through the novel mechanism of choice of trade regime, less efficient firms in labor-abundant countries are very likely stuck in processing trade. To this line of research, the model illustrates that productivity constraint impedes firms' export outcomes and profits. The analysis of processing exporters is also related to the literature studying trade policy in a heterogeneous-firm setting (Fan et al., 2013; Lu et al., 2014; Ma et al., 2014). From this point, the theoretical model demonstrates that the reallocation process is hindered, and thus trade liberalization fail to generate aggregate productivity gains in industries when processing trade is pervasive.

This paper is organized as follows. Section 2 presents the institutional background on processing trade regime in China. Section 3 introduces the model and characterizes the equilibrium with two asymmetric countries. Section 4 discusses the impact of trade liberalization on productivity cutoffs and welfare. Section 5 concludes.

2.2 Institutional Background

In the hopes of obtaining foreign technology, utilizing abundant labor force and boosting economic growth, China has employed a wide range of trade instruments to stimulate export activity and attract FDI since the beginning of the 1980s. An essential intervention is the attraction of FIEs carrying out processing trade. In place since the 1980s, the provision of this policy has resulted in a far-reaching reshuffle of industrial production at the world level. China has become a world factory and climbed to the top of the world exporters, contributing for more than 10 percent of the global trade

volume (the sum of exports and imports) in 2010. More importantly, processing trade constitutes almost one-half of China's total trade and becomes the primary contributor to China's trade surplus.

The prevalence of processing trade can be directly attributed to the following factors: the establishment of Free Trade Zones (FTZs)² and the attraction of FDI. In the 1980s, the Chinese authority selected some coastal cities as Special Economic Zones (SEZs) to stimulate trade. FIEs were strongly encouraged to locate in these zones and to engage in processing trade. Additionally, the export-oriented firm (with the export volume more than fifty percent) invested by foreign investors likewise granted additional benefits such as reduced corporate income tax rate, preferential land-use policies, easier access to finance and foreign market. In particular, enterprises located in SEZs were free to use the vast Chinese pool of low-cost labor, which was different from the prevailing Chinese lifetime system of public or collective firms. These policies have proven to be highly efficient, resulting in the increase of China's share in world trade from 1.1 percent to 1.9 percent by the end of 1989.

Since the 1990s, the labor-intensive stage of industrial production has been relocated from high-wage countries to low-wage ones, which have specialized in assembly. To actively participate in this new form of division of labor and integrate into the global production network, China deepened its trade reform and broadened the opening-up in early of 1992. Policies with the similar privileges were extended to inland and western provinces. Various economic development zones and high-tech development zones were also established in central and western China. Moreover, China progressively lowered foreign investors' import duties and entry barriers. These measures have led to impressive FDI flows to China and given rise to the massive investment in manufacturing industry. FIEs accelerate the Chinese manufacturing industry into the global production chain as they fragmented large parts of their production processes via arms-length contracts or subsidiaries. Notably, FIEs overwhelmingly accounted for 70 percent of processing trade in China in the first decade of the 21st century. This highlights the essential role of foreign firms in China's ballooning trade surplus.

The most direct and profound policy in promoting processing trade and enhancing export is the establishment of a series of Export Processing Zones (EPZs) in the year 2000, one year before China joined the WTO. Chinese private firms, State-Owned Enterprises (SOEs) and FIEs are all encouraged to locate in the EPZs, but all firms are only allowed to engage in processing trade. The production inputs entering the EPZs are duty-free, and the final assembled product for export are exempted from

²The FTZs in China include: Special Economic Zones (SEZs), Economics and Technological Development Zones (ETDZs), High-Technology Industrial Development Zones (HTIDZs), Export Processing Zones (EPZs), Open coastal/riverside/inland/border city, Border Economic Cooperation Zone (BECZ), Bounded Zone/Logistics Park.

value-added tax. Furthermore, firms enjoy other preferential policies as streamlined regulations, minimal administrative costs, and finance facilities. In other words, the EPZs in China are very simple zones that have the highest levels of openness in the country (Fu and Gao, 2007). However, to obtain these benefits, all firms located in the EPZs must export 70 percent of their output. The set up of the EPZs substantially encourages MNEs to transfer their labor-intensive stage to China. The rapid expansion of EPZs in China has led to a great leap forward of foreign trade in China, accounting for almost 9 percent of the world export in 2008.

In summary, the creation of processing trade regime has significantly contributed to China's export growth. Foreign firms are the key determinants to the expansion of processing trade. The establishment of a large number of FTZs further consolidates its superior export performance.

2.3 Theoretical Framework

The model extends Melitz (2003) to a world of two large asymmetric countries, China and Foreign Country indexed by $i \in \{c, f\}$ accordingly. Each country is populated by L_i identical household. Labor is the only factor of production. Each household inelastically supplies one unit of labor and earns wage w_i . I assume that China is a labor-abundant country, having a lower wage than that of the Foreign Country ($w_c < w_f$). The size of the two economies is equal ($L_c = L_f = L$).

2.3.1 Demand

The preference of a representative consumer in country i are given by a CES utility function over a continuum of goods indexed by ω :

$$U_i = \left[\int_{\omega \in \Omega_i} q_i(\omega)^\rho d\omega \right]^{\frac{1}{\rho}}, \quad i \in \{c, f\} \quad (2.1)$$

where the measure of the set Ω_i represents the mass of available varieties in country i . These goods are substitutes, which implies $0 < \rho < 1$ with the elasticity of substitution between any two pair of goods having $\sigma = \frac{1}{1-\rho} > 1$. Following Dixit and Stiglitz (1977), consumer behavior can be modeled by considering the set of varieties consumed as an aggregate good $Q_i \equiv U_i$ associated with an aggregate price in country i

$$P_i = \left[\int_{\omega \in \Omega_i} p_i(\omega)^{1-\sigma} d\omega \right]^{\frac{1}{1-\sigma}}. \quad (2.2)$$

The assumption of *CES* preference indicates that the consumer has “taste for variety” in that she/he prefers to consume a diversified bundle of goods. Moreover, even if each variety is priced differently, adding a new one increases utility if prices of the existing

varieties are unchanged. Given these presences, the revenue of a variety ω in country i is

$$r_i(\omega) = R_i \left[\frac{p_i(\omega)}{P_i} \right]^{1-\sigma}, \quad (2.3)$$

where $R_i = P_i Q_i = \int_{\omega \in \Omega_i} r_i(\omega) d\omega$ is the aggregate expenditure in country i ; $p_i(\omega)$ denotes the price of variety ω in the domestic market i ; the price index P_i summarizes the prices of competing varieties.

2.3.2 Production

There is a continuum of firms, each choosing to produce a different variety ω with productivity φ . Production involves fixed overhead costs and variable costs in each period. Production requires only one factor, labor, which is inelastically supplied at its aggregate level L_i , an index of the country i 's size. A firm in country i pays the fixed market access costs $f_x w_i$ to serve consumers in country j . I denote the fixed costs of serving domestic market by $f_d w_i$, which includes “market access” costs into the domestic market.³ Exporting involves symmetric iceberg trade costs, where $\tau \geq 1$ units of a good must be shipped in order for one unit to arrive. All firms in both countries face the fixed overhead costs $f w_i$, and vary in firm productivity, $\varphi \in (0, \infty)$.

In particular, a Chinese firm chooses to either pursue processing trade or regular production mode. A processing exporter engages in processing trade which exports all of its product by paying beachhead costs $f w_c$. On the other hand, a regular producer that can cover beachhead costs $f w_c$, and domestic trade costs $f_d w_c$ serves the Chinese domestic market. Some of these regular producers that can pay the additionally fixed export costs $f_x w_c$ exporting to Foreign Country. Notably, I assume that firms in Foreign Country only operate domestically or as regular exporters.

Processing exporters are engaged in processing trade, and it is only implemented in China. Under this regime, the duty of the imported input is waived, and the processed goods are not allowed to be sold in Chinese market. Processing exporters thus pay for manufactured input and labor, and foreign buyers are responsible for the marketing and distribution of the final goods. In other words, processing exporters only need to bear the production costs $f w_c$ and the transportation costs $\tau > 1$. The fixed domestic trade costs $f_d w_c$ and the fixed export costs $f_x w_c$ are waived from their costs structure, owing to the definition of processing trade. By contrast, the up-front expenditures are highest for a regular exporter that bears all domestic trade costs $f_d w_c$, export distribution outlays associated with production $f w_c$, fixed export costs $f_x w_c$ and the

³As stated by (Melitz and Redding, 2014), with positive domestic access costs, it can be profitable in principle for firms to export but not to serve the domestic market.

transportation costs $\tau > 1$. A non-exporter that only focuses on the domestic market has lower up-front expenses as it entails beachhead costs fw_c and domestic trade costs $f_d w_c$.

The technology of a firm is represented by a cost function which exhibits constant marginal cost with some fixed costs. The labor used is thus a linear function of output q

$$l = \left(F + \frac{q}{\varphi}\right)w_i, \quad (2.4)$$

where $F \in \{f, f + f_d, f + f_d + f_x\}$. The profit maximization yields the standard condition that a firm's output price is a constant markup over its marginal cost

$$\begin{aligned} p_c^s(\varphi) &= \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi} w_c, \\ p_c^d(\varphi) &= \frac{\sigma}{\sigma - 1} \frac{1}{\varphi} w_c, \\ p_c^x(\varphi) &= \frac{\sigma}{\sigma - 1} \frac{\tau}{\varphi} w_c, \end{aligned} \quad (2.5)$$

where $p_c^s(\varphi)$ is the price charged by a Chinese processing exporter in Foreign Country; $p_c^d(\varphi)$ is the price charged by a domestic Chinese firm in its own market, and $p_c^x(\varphi)$ is the price charged by a regular Chinese exporter in Foreign Country. All exporting firms face the traditional iceberg transportation costs where $\tau > 1$ units of a good must be shipped in order for one unit to arrive at its destination.

Substituting the pricing rule into firm revenue equation in 2.3, I obtain the following expression of a Chinese firm revenue in a different market:

$$\begin{aligned} r_c^s(\varphi) &= (\tau w_c)^{1-\sigma} R_f \left(P_f \rho \varphi\right)^{\sigma-1}, \\ r_c^d(\varphi) &= w_c^{1-\sigma} R_c \left(P_c \rho \varphi\right)^{\sigma-1}, \\ r_c^x(\varphi) &= (w_c \tau)^{1-\sigma} R_f \left(P_f \varphi \rho\right)^{\sigma-1}, \end{aligned} \quad (2.6)$$

where $r_c^s(\varphi)$ stands for the total revenue of a Chinese processing exporter gained in Foreign Country; the equilibrium revenue of a Chinese regular producer in the domestic market is $r_c^d(\varphi)$, and in the export market is $r_c^x(\varphi)$.

Let $k \in \{d, x, s\}$ index the three possible modes of production: domestic, regular and processing export, respectively. The maximum level of profits that a Chinese firm with productivity φ using operation mode k can attain is given by:

$$\pi_c^k(\varphi) = \begin{cases} \frac{r_c^d(\varphi)}{\sigma} - (f_d + f)w_c & \text{only serves the domestic market} \\ \frac{r_c^d(\varphi)}{\sigma} + \frac{r_c^x(\varphi)}{\sigma} - (f_d + f_x + f)w_c & \text{serves both markets} \\ \frac{r_c^s(\varphi)}{\sigma} - f w_c & \text{only serves the Foreign Country} \end{cases}$$

The departure of the model from Melitz (2003) is the additional assumption of the domestic trade costs f_d . In Melitz (2003), an integrated domestic market which involves

no trade costs is assumed. Owing to the costs saving advantage, less-productive firms earn non-negative profits exclusively from the domestic market. Such an assumption is reasonable since conducting international business is much harder than building business relations at home in a unified market. However, Chinese domestic market is segmented by provincial border; the productivity premium is also needed to enter other domestic provincial markets. Naughton (2003) states that local government does not block the border or impose any tariffs. But the government's pervasive political power enables it to impose significant non-tariff barriers which substantially increases the costs of trade and impedes cross-provincial border trade.⁴ Therefore, generalized the current theoretical model to capture the salient feature of high domestic trade costs f_d is very reasonable.

Foreign firms are similar to Chinese firms. The price charged by a foreign firm in its domestic market is $p_f^d = \frac{\sigma}{\sigma-1} \frac{1}{\varphi} w_f$. The price of a product from Foreign Country exported to Chinese market is $p_f^x = \frac{\sigma}{\sigma-1} \frac{\tau}{\varphi} w_f$. Thus, the revenue earned from domestic sales and export sales to Chinese market are, respectively, $r_f^d(\varphi) = w_f^{1-\sigma} R_f (P_f \rho \varphi)^{\sigma-1}$ and $r_f^x(\varphi) = (w_f \tau)^{1-\sigma} R_c (P_c \varphi \rho)^{\sigma-1}$, where R_i and P_i denote the aggregate expenditure and price index in country $i \in \{c, f\}$. The combined revenue of a foreign firm, $r_f(\varphi)$, thus depends on its export status:

$$r_f(\varphi) = \begin{cases} r_f^d(\varphi) & \text{if the firm does not export} \\ r_f^d(\varphi) + r_f^x(\varphi) & \text{if the firm exports.} \end{cases}$$

As illustrated before, foreign firms can only operate domestically or as regular exporters, therefore, no foreign firms ever export and not also produce for its domestic market. Each firm's profit is separated into portions earned from domestic sales $\pi_f^d(\varphi)$ and export sales $\pi_f^x(\varphi)$ by accounting the entirely overhead production costs in domestic profit:

$$\pi_f^d(\varphi) = \frac{r_f^d(\varphi)}{\sigma} - (f_d + f)w_f; \quad \pi_f^x(\varphi) = \frac{r_f^x(\varphi)}{\sigma} - f_x w_f.$$

A foreign firm that produces for its domestic market and exports if $\pi_f^x(\varphi) \geq 0$. Each firm's combined profits can then be written as $\pi_f(\varphi) = \pi_f^d(\varphi) + \max\{0, \pi_f^x(\varphi)\}$.

2.3.3 Firm Entry, Exit and Export Status

To produce in country $i \in \{c, f\}$, firms must make an initial investment $f_e w_i > 0$ (measure in units of labor), which is thereafter sunk. Firms then draw their productivity φ from a distribution $g(\varphi)$, with cumulative distribution $G(\varphi)$, which is assumed

⁴The types of domestic trade barriers include physical barriers, outright prohibition through administrative decree, financial benefits for firms selling local goods, local purchasing quotas, poor infrastructure and business conditions, less efficient government. Domestic trade barriers are not specific to China. For example, in Russia, regional government limits beer import from other regions (Gurieva et al., 2007; Wong, 2012; Pflüger and Russek, 2013).

to be common across countries. Firms then face an exogenous probability δ of death each period. An entering firm with productivity φ would then immediately exit if its profit level is negative, or would produce and earn $\pi_i \geq 0, i \in \{c, f\}$ in every period until it is hit with a bad shock and is forced to exit. Assuming that there is no time discounting, each firm's value function is given by:

$$v_i(\varphi) = \max \left\{ 0, \sum_{t=0}^{\infty} (1 - \delta)^t \pi_i(\varphi) \right\} = \max \left\{ 0, \frac{1}{\delta} \pi_i(\varphi) \right\}.$$

Thus, $\varphi_i^* = \inf \{ \varphi : v_i(\varphi) > 0 \}$ identifies the lowest productivity level (hereafter referred to the cutoff level) of producing firms. Since $\pi_i(0) = -f$ is negative, $\pi_i(\varphi^*)$ must be equal to zero. This will be referred to the zero cutoff profit condition.

In particular, a Chinese firm obtains the information about its productivity level φ once the fixed entry costs $f_e w_c$ are paid. The cutoff productivity levels φ_s^* , φ_d^* and φ_x^* that identify processing exporters, domestic firms, and regular exporters:

$$\varphi_s^{*\sigma-1} = \frac{\sigma f w_c}{R_f \left(\frac{\tau w_c}{P_f} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}}, \quad (2.7)$$

$$\varphi_d^{*\sigma-1} = \frac{\sigma(f + f_d) w_c}{R_c \left(\frac{w_c}{P_c} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}}, \quad (2.8)$$

$$\varphi_x^{*\sigma-1} = \frac{\sigma f_x w_c}{R_f \left(\frac{\tau w_c}{P_f} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}}. \quad (2.9)$$

These three cutoffs are, respectively, the productivity level above which a Chinese firm would find it profitable to produce solely for Foreign Country $\{\pi_c^s(\varphi) = 0\}$, and the productivity level necessary for a firm to choose to become a domestic producer $\{\pi_c^d(\varphi) = 0\}$. Additionally, $\varphi_x^* = \inf \{ \varphi : \varphi \geq \varphi_d^* \text{ and } \pi_c^x(\varphi) > 0 \}$ represents the cutoff productivity level for regular exporting Chinese firms.

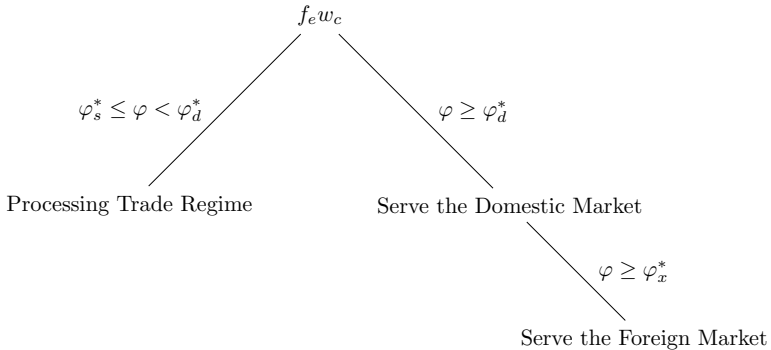


Figure 2.1: Choice of production mode in China

As shown in Figure 2.1, successful entrants choose to engage in processing trade or regular production mode based on their idiosyncratic productivity. In accordance with the empirical evidence that Chinese processing exporters are the least efficient surviving firms and exporters tend to be more productive than domestic firms, I must have

$$\tau^{\sigma-1} f R_c P_c^{\sigma-1} < (f + f_d) R_f P_f^{\sigma-1} < \tau^{\sigma-1} f_x R_c P_c^{\sigma-1}, \quad (2.10)$$

which recaps the partitioning of firms $0 < \varphi_s^* < \varphi_d^* < \varphi_x^*$. That is, a Chinese firm, the productivity of which covering the fixed production costs serves Foreign Country only. A Chinese firm, the productivity of which is able to pay for the production and fixed domestic trade costs, chooses to serve the domestic market. A Chinese firm drawing a sufficiently high productivity chooses to serve both markets.

Any entering Chinese firm drawing a productivity level $\varphi < \varphi_s^*$ immediately exit and never produce. The equilibrium productivity distribution $\mu_c(\varphi)$ of Chinese firms is determined by the initial productivity draw, conditional on successful entry:

$$\mu_c(\varphi) = \begin{cases} \frac{g(\varphi)}{1-G(\varphi_s^*)} & \text{if } \varphi \geq \varphi_s^* \\ 0 & \text{otherwise} \end{cases}$$

and $p_c^{in} \equiv 1 - G(\varphi_s^*)$ is the Chinese firms' *ex ante* probability of successful entry to the industry. Therefore, the average productivity levels of processing exporters $\tilde{\varphi}_c^s(\varphi_s^*)$, non-exporters $\tilde{\varphi}_c^d(\varphi_d^*)$, and regular exporters $\tilde{\varphi}_c^x(\varphi_x^*)$ in China are defined as:

$$\tilde{\varphi}_c^s(\varphi_s^*) = \left[\frac{1}{G(\varphi_d^*) - G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}, \quad (2.11)$$

$$\tilde{\varphi}_c^d(\varphi_d^*) = \left[\frac{1}{1 - G(\varphi_d^*)} \int_{\varphi_d^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}, \quad (2.12)$$

$$\tilde{\varphi}_c^x(\varphi_x^*) = \left[\frac{1}{1 - G(\varphi_x^*)} \int_{\varphi_x^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}. \quad (2.13)$$

These equations show how the shape of equilibrium distribution of productivity levels is tied to the exogenous *ex ante* distribution $g(\varphi)$ while allowing the range of productivity levels (indexed by the cutoffs) to be endogenously determined.

Chinese firms' decisions concerning production for the domestic and foreign markets are summarized graphically in Figure 2.2. In addition, $p_c^s = \frac{G(\varphi_d^*) - G(\varphi_s^*)}{1 - G(\varphi_s^*)}$ denotes the probability of being processing exporters, conditional on successful entry. Similarly, $p_c^d = \frac{1 - G(\varphi_d^*)}{1 - G(\varphi_s^*)}$ represents the *ex ante* probability that one of these successful firms engages in regular production mode; while $p_c^x = \frac{1 - G(\varphi_x^*)}{1 - G(\varphi_d^*)}$ denotes the probability of exporting conditional on serving the domestic market. Furthermore, M_c is the mass of producing firms and M_c^e is the mass of entrants in China. Consequently, the mass of

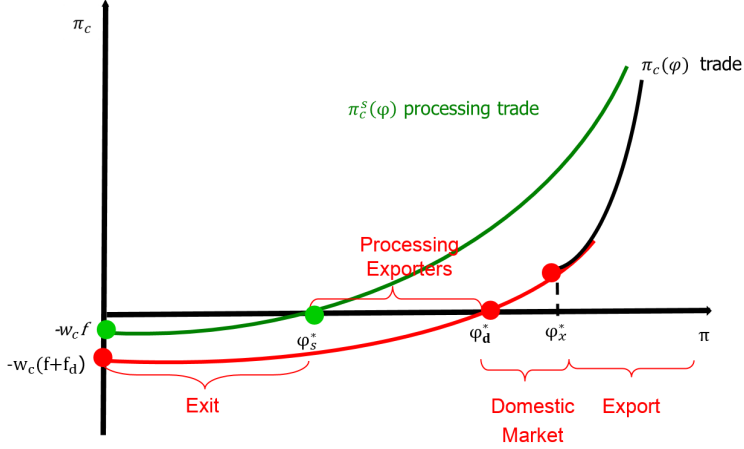


Figure 2.2: Zero-profit, processing exporting and regular exporting productivity in China

processing exporters, domestic firms and exporting firms in China are represented by $M_c^s = p_c^s M_c$, $M_c^d = p_c^d M_c$, and $M_c^x = p_c^x M_c^d$, respectively.

Foreign firms follow the conventional pattern in literature. Once the sunk costs of entry $f_e w_f$ are paid, a firm draw its productivity φ from a fixed distribution $g(\varphi)$. There are two cutoff productivities, the domestic zero profit productivity, φ_{df}^* , above which firms produce for their own domestic market; and the exporting productivity cutoff, φ_{xf}^* , above which firms serve both markets:

$$\varphi_{df}^{*\sigma-1} = \frac{\sigma(f + f_d)w_f}{R_f \left(\frac{w_f}{P_f} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}}, \quad (2.14)$$

$$\varphi_{xf}^{*\sigma-1} = \frac{\sigma f_x w_f}{R_c \left(\frac{\tau w_f}{P_c} \frac{\sigma}{\sigma-1} \right)^{1-\sigma}}. \quad (2.15)$$

The conventional sorting condition of selection into export market ($\varphi_{xf}^* > \varphi_{df}^*$) requires strictly positive fixed exporting costs and sufficient high values of both fixed and variable trade costs: $\tau^{\sigma-1} f_x R_f P_f^{\sigma-1} > (f + f_d) R_c P_c^{\sigma-1}$. In this sense, the revenue needed to serve the export market is larger relative to the revenue needed to cover the domestic trade costs.

Foreign firms' decision concerning production for their own domestic market and Chinese market are summarized graphically in Figure 2.3. Of the mass of foreign firms, M_f , $G(\varphi_{df}^*)$, draw a productivity level sufficient low that they are unable to cover any costs and exit the industry immediately; a fraction, $G(\varphi_{xf}^*) - G(\varphi_{df}^*)$, draw an intermediate productivity such that they could afford the cost of production and domestic trade barriers and serve its own domestic market; a fraction, $1 - G(\varphi_{xf}^*)$, has a sufficient high productivity level that it is profitable to serve both markets.

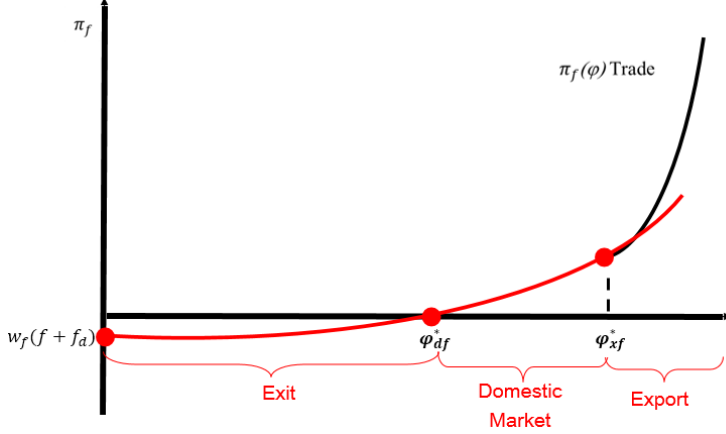


Figure 2.3: Zero-profit and exporting productivity in Foreign Country.

Once again, the equilibrium distribution of productivity for incumbent firms, $\mu_f(\varphi) = g(\varphi)/[1 - G(\varphi_{df}^*)] \forall \varphi \geq \varphi_{df}^*$, is determined by *ex ante* probability of firm productivity based on successful entry. The *ex ante* probability of exporting to China is then $p_f^x = \frac{1 - G(\varphi_{xf}^*)}{1 - G(\varphi_{df}^*)}$. Accordingly, the aggregate productivity levels for foreign domestic firms and exporters are defined as:

$$\tilde{\varphi}_f^d(\varphi_{df}^*) = \left[\frac{1}{1 - G(\varphi_{df}^*)} \int_{\varphi_{df}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}, \quad (2.16)$$

$$\tilde{\varphi}_f^x(\varphi_{xf}^*) = \left[\frac{1}{1 - G(\varphi_{xf}^*)} \int_{\varphi_{xf}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \right]^{\frac{1}{\sigma-1}}. \quad (2.17)$$

Analogously to China, the total number of producing firms is denoted by M_f and the mass of exporting firms is $M_f^x = p_f^x M_f$ in Foreign Country. However, the total number of firms competing in Foreign Country is $M_f + M_c^s + M_c^x$, which implies the mass of producing firms is not equal to the total varieties available to consumers in Foreign Country ($M_f \neq M_c^s + M_c^x + M_f$). Similarly, the total mass of varieties available to consumers in China is $M_c^d + M_f^x$, which indicates the total varieties that produced in China is not equal to the total varieties available to Chinese consumer ($M_c \neq M_c^d + M_f^x$).

The construction of productivity averages in both regions can also be used to express the average profit and revenue across different types of firms. Specifically, $r_c^s(\tilde{\varphi}_c^s)$ and $\pi_c^s(\tilde{\varphi}_c^s)$ represent the average revenue and profit earned by Chinese processing exporters from sales in Foreign Country, whereas $r_i^d(\tilde{\varphi}_i^d)$ and $\pi_i^d(\tilde{\varphi}_i^d)$ describe the average revenue and profit obtained by domestic firms in their own country. Similarly, $r_i^x(\tilde{\varphi}_i^x)$ and $\pi_i^x(\tilde{\varphi}_i^x)$ depict the average export revenue and profit earned by domestic regular exporters. The overall average, across all types of firms, of combined revenue, earned

from both markets, is thus given by:

$$\bar{r}_c = p_c^s \sigma f w_c \left(\frac{\tilde{\varphi}_c^s}{\varphi_s^*} \right)^{\sigma-1} + p_c^d \sigma w_c \left[(f + f_d) \left(\frac{\tilde{\varphi}_c^d}{\varphi_d^*} \right)^{\sigma-1} + p_c^x f_x \left(\frac{\tilde{\varphi}_c^x}{\varphi_x^*} \right)^{\sigma-1} \right], \quad (2.18)$$

$$\bar{r}_f = \sigma (f + f_d) w_f \left(\frac{\tilde{\varphi}_f^d}{\varphi_{df}^*} \right)^{\sigma-1} + p_f^x \sigma f_x w_f \left(\frac{\tilde{\varphi}_f^x}{\varphi_{xf}^*} \right)^{\sigma-1}. \quad (2.19)$$

The partitioning of firms by export status in both countries can be obtained if and only if $\tau^{\sigma-1} f < f + f_d < \tau^{\sigma-1} f_x$, which requires $R_f P_f^{\sigma-1} = R_c P_c^{\sigma-1}$ is satisfied. That is, beachhead costs with variable export costs are relatively small to production costs plus the domestic trade costs, while export trade costs must be above it, based on $R_f P_f^{\sigma-1} = R_c P_c^{\sigma-1}$ is holding. Satisfying these conditions make the model generates partitioning of the coexistence, within a narrowly defined industry, of processing exporters, non-exporters, and regular exporters. More importantly, the holding of $R_f P_f^{\sigma-1} = R_c P_c^{\sigma-1}$ draws special attention. Substituting the total revenue R_i with total labor income $R_i = w_i L$ and $w_c < w_f$ yields $P_f^{\sigma-1} < P_c^{\sigma-1}$ and $R_f > R_c$. That is, the price index in China, P_c , is high relative to the foreign price index, P_f , and Foreign Country has a lower true costs of living index and a higher utility level relative to China ($U_f > U_c$). In other words, as a consequence of a very large proportion of processing trade, Chinese consumers are faced with higher prices while foreign consumers reap the benefits of cheap processed goods.

2.3.4 Equilibrium Conditions

The zero cutoff profit conditions in both countries imply a relationship between the average profit per firm and the cutoff productivity levels:

$$\begin{aligned} \pi_c^s(\varphi_s^*) = 0 & \iff \pi_c^s(\tilde{\varphi}_c^s) = f w_c k(\varphi_s^*), \\ \pi_c^d(\varphi_d^*) = 0 & \iff \pi_c^d(\tilde{\varphi}_c^d) = (f + f_d) w_c k(\varphi_d^*), \\ \pi_c^x(\varphi_x^*) = 0 & \iff \pi_c^x(\tilde{\varphi}_c^x) = f_x w_c k(\varphi_x^*), \end{aligned}$$

where $k(\varphi) = [(\tilde{\varphi}(\varphi)/\varphi)^{\sigma-1} - 1]$. The expression for the corresponding variables of foreign firms are defined analogously:

$$\begin{aligned} \pi_f^d(\varphi_{df}^*) = 0 & \iff \pi_f^d(\tilde{\varphi}_f^d) = (f + f_d) w_f k(\varphi_{df}^*), \\ \pi_f^x(\varphi_{xf}^*) = 0 & \iff \pi_f^x(\tilde{\varphi}_f^x) = f_x w_f k(\varphi_{xf}^*). \end{aligned}$$

The zero cutoff profit conditions also imply that all other cutoff productivity levels can be written as a function of domestic cutoff productivity:

$$\frac{r_c^s(\varphi_s^*)}{r_c^d(\varphi_d^*)} = \tau^{1-\sigma} \left(\frac{\varphi_s^*}{\varphi_d^*} \right)^{\sigma-1} = \frac{f}{f + f_d} \iff \varphi_s^* = \varphi_d^* \tau \left(\frac{f}{f + f_d} \right)^{\frac{1}{\sigma-1}}, \quad (2.20)$$

$$\frac{r_c^x(\varphi_x^*)}{r_c^d(\varphi_d^*)} = \tau^{1-\sigma} \left(\frac{\varphi_x^*}{\varphi_d^*} \right)^{\sigma-1} = \frac{f_x}{f + f_d} \quad \Longleftrightarrow \quad \varphi_x^* = \varphi_d^* \tau \left(\frac{f_x}{f + f_d} \right)^{\frac{1}{\sigma-1}}, \quad (2.21)$$

$$\frac{r_f^x(\varphi_{xf}^*)}{r_f^d(\varphi_{df}^*)} = \tau^{1-\sigma} \left(\frac{\varphi_{xf}^*}{\varphi_{df}^*} \right)^{\sigma-1} = \frac{f_x}{f + f_d} \quad \Longleftrightarrow \quad \varphi_{xf}^* = \varphi_{df}^* \tau \left(\frac{f_x}{f + f_d} \right)^{\frac{1}{\sigma-1}}. \quad (2.22)$$

Hence, the average profit flow for a surviving firm in China and Foreign Country are, respectively,

$$\begin{aligned} \bar{\pi}_c &= p_c^s \pi_c^s(\tilde{\varphi}_c^s) + p_c^d (\pi_c^d(\tilde{\varphi}_c^d) + p_c^x \pi_c^x(\tilde{\varphi}_c^x)) \\ &= p_c^s f w_c k(\varphi_s^*) + p_c^d ((f + f_d) w_c k(\varphi_d^*) + p_c^x f_x w_c k(\varphi_{xf}^*)), \end{aligned} \quad (\text{ZCP1})$$

$$\begin{aligned} \bar{\pi}_f &= \pi_f^d(\tilde{\varphi}_f^d) + p_f^x \pi_f^x(\tilde{\varphi}_f^x), \\ &= (f + f_d) w_f k(\varphi_{df}^*) + p_f^x f_x w_f k(\varphi_x^*), \end{aligned} \quad (\text{ZCP2})$$

where all other cutoff productivity levels and fractions of exporting firms are implicitly defined as a function of domestic cutoff level using equations (2.20) -2.22. The equations (ZCP1) and (ZCP2) thus identify the zero cutoff profit conditions for China and Foreign Country.

2.3.5 Determination of the Equilibrium

The potential entrants enter the industry until the expected value of entry, V_i , equals the sunk entry costs, $f_e w_i$. The expected value of entry V_i is the *ex ante* probability of successful entry, $1 - G(\varphi_i)$, multiplied by the expected profits of producing goods until death. Hence, the free entry conditions for China and Foreign Country are

$$V_c = \frac{1 - G(\varphi_s^*)}{\delta} \bar{\pi}_c = f_e w_c, \quad (\text{FE1})$$

$$V_f = \frac{1 - G(\varphi_{df}^*)}{\delta} \bar{\pi}_f = f_e w_f, \quad (\text{FE2})$$

where $\bar{\pi}_i$ is the average firm profit from successful entry. In particular, some low productive Chinese firms fully export to Foreign Country, while some intermediate productive Chinese firms concentrate on domestic market. With the definition of weighted average productivity above, the free entry conditions in China and Foreign Country can be rewritten as a function solely of the zero profit productivity and parameters of the model:

$$f_e = \frac{f}{\delta} J(\varphi_s^*) + \frac{f + f_d}{\delta} J(\varphi_d^*) + \frac{f_x}{\delta} J(\varphi_x^*), \quad (2.23)$$

$$f_e = \frac{f + f_d}{\delta} J(\varphi_{df}^*) + \frac{f_x}{\delta} J(\varphi_{xf}^*), \quad (2.24)$$

$$J(\varphi_s^*) = \int_{\varphi_s^*}^{\varphi_d^*} \left[\left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi, \quad J(\varphi_i^*) = \int_{\varphi_i^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_i^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi.$$

Using the relationship between productivity cutoffs (2.20) - (2.22), and noting that $J(\cdot)$ is a decreasing function, the above free entry conditions identify unique equilibrium values of domestic cutoffs for China and Foreign Country (φ_d^* and φ_{df}^*). These in turn determine export productivity cutoffs (φ_s^* , φ_x^* and φ_{xf}^*) as well as average productivity levels and the *ex ante* successful entry and export probabilities. In addition, the increase in fixed production costs, f , fixed domestic trade costs, f_d , and fixed export costs, f_x , raise the productivity cutoff levels φ_d^* and φ_{df}^* in both regions. The higher fixed costs indicate that firms must draw a higher productivity to earn sufficient revenue to overcome these costs. On the other hand, raising these costs reduce the mass of goods produced, improve firms' *ex post* profitability, and therefore increases the probability of less productive firms surviving in the industry.

In a stationary equilibrium with constant mass of operating firms, the mass of successful new entrants must equal the mass of incumbents that die: $[1 - G(\varphi_i^*)]M_i^e = \delta M_i$. Product variety in a destination is given by the total mass of sellers. Hence, the price index in China and Foreign Country is the CES aggregate of the prices of all of these goods:

$$P_c = \left[M_c^d p_c^d (\tilde{\varphi}_c^d)^{1-\sigma} + M_f^x p_f^x (\tilde{\varphi}_f^x)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \quad (2.25)$$

$$P_f = \left[M_f p_f^d (\tilde{\varphi}_f^d)^{1-\sigma} + M_c^x p_c^x (\tilde{\varphi}_c^x)^{1-\sigma} + M_c^s p_c^s (\tilde{\varphi}_c^s)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \quad (2.26)$$

where M_i^k is the mass of operating firm choosing production mode k in country i . Notice that M_c^s denotes the varieties produced by Chinese processing exporters but only consumed in Foreign Country. As a result, the price indices vary across these two regions.

The comparison of industry cutoff productivity (2.7) and domestic productivity thresholds in China (2.8) and Foreign Country (2.14) reveals $\varphi_s^* < \varphi_d^* < \varphi_{df}^*$. This implies that firms located in Foreign Country have better accesses to obtaining a productivity above any cutoff level, and that only more productive firms can survive. By contrast, *ex ante* Chinese firms draw lower productivity levels relative to their counterpart in Foreign Country. The productivity cutoff level of surviving Foreign firms, φ_{df}^* , is therefore higher than φ_s^* . Foreign firms face more severe competition both from Chinese processing and regular exporters compared to that faced by Chinese firms in its own market, result in $\varphi_x^* < \varphi_{xf}^*$. In particular, firms in Foreign Country with better productivity distribution is associated with higher productivity, a lower price index and a higher welfare per worker relative to that of China. These results fit the empirical feature that China is a technology inferior country relative to developed countries, e.g. the US.

The labor market clearing condition requires that, in both countries, total labor used for production and the investment (by new entrants) must equal the total labor

endowment

$$L = M_i^e f_e + M_i \left(\int l_i^k(\varphi) d\mu_i(\varphi) \right), \quad i \in \{c, f\},$$

where $\mu_i(\varphi)$ is the *ex post* distribution of operating firms across productivity levels in country i , and l_i^k is the optimal labor demand for a firm with productivity φ using production mode k in country i . The mass of producing firms, M_i , can be determined from the ratio of aggregate revenue, R_i , to average firm revenue:

$$M_c = \frac{R_c}{\bar{r}_c} = \frac{L}{\sigma \left(p_c^s f \left(\frac{\tilde{\varphi}_c^s}{\varphi_{cs}^*} \right)^{\sigma-1} + p_c^d \left[(f + f_d) \left(\frac{\tilde{\varphi}_c^d}{\varphi_{cd}^*} \right)^{\sigma-1} + p_c^x f_x \left(\frac{\tilde{\varphi}_c^x}{\varphi_{cx}^*} \right)^{\sigma-1} \right] \right)}, \quad (2.27)$$

$$M_f = \frac{R_f}{\bar{r}_f} = \frac{L}{\sigma \left((f + f_d) \left(\frac{\tilde{\varphi}_f^d}{\varphi_{df}^*} \right)^{\sigma-1} + p_f^x f_x \left(\frac{\tilde{\varphi}_f^x}{\varphi_{xf}^*} \right)^{\sigma-1} \right)}. \quad (2.28)$$

Other things equal, the rise in average productivity following the opening of trade reduces the mass of domestically produced varieties. The trade balance condition is derived from labor market clearing, free entry, zero-profit productivity cutoff conditions and the requirement that trade is balanced:

$$r_c^f(\tilde{\varphi}_c^x) M_c^x + r_c^s(\tilde{\varphi}_c^s) M_c^s = r_f^x(\tilde{\varphi}_f^x) M_f^x. \quad (2.29)$$

To put it another way, the total value of China's manufacturing export must equal the value of manufacturing import produced by foreign firms.

The equilibrium is referenced by a vector of variables in China and Foreign Country: $\{\varphi_s^*, \varphi_d^*, \varphi_x^*, \varphi_{df}^*, \varphi_{xf}^*\}$. All other endogenous variables (M_c, M_f, P_c, P_f) can be written as functions of these quantities such that the labor market is clearing, free entry and aggregate expenditure equations are satisfied in both countries and the balance trade condition holds. I show in Appendix 2.6.2 that there exists a unique equilibrium.

2.4 Impact of Trade Liberalization

The preceding analysis has shown that the presence of processing trade along with the fixed domestic trade costs and export entry costs can induce a partitioning of firms by export status, based on firm productivity. Nevertheless, this result is not exactly surprising. The current model is well-suited to address several important issues concerning the impact of trade liberalization with the existence of processing trade and firm heterogeneity: do all firms within a sector benefit from trade, or does the impact depend on firm productivity? How are the aggregate productivity and welfare affected in the presence of processing trade? What happens to the range of firm

productivity levels? In particular, this model is much better suited to tackle several different mechanisms that would produce an increase in trade exposure and plausibly correspond to the observed decreases in trade cost over time or some specific policies to liberalized trade. The effects of such mechanisms are investigated: a decrease in either fixed or variable export trade costs and a reduction in domestic trade costs. These three scenarios involve comparative statics of the open economy equilibrium with respect to f_x , τ and f_d . I show that trade liberalization in fixed export costs (f_d) force the least productive Chinese processing exporters to exit, while simultaneously raises domestic productivity levels in both countries. Moreover, falling variable export costs (τ) generate similar result relative to the decrease of f_x . The only difference is that the industry cutoff productivity level has decreased in China. Besides, a more integrated domestic market forces the least productive Chinese processing exporters to exit and has an overall positive impact on welfare in both regions. In summary, all these changes unequivocally deliver welfare gains and nations always benefit from freer trade.

2.4.1 Decreases in Fixed Export Costs

I first investigate the effect of a decrease in the fixed export costs f_x . Throughout the comparative static analysis, I have used the old notation to describe the old equilibrium. I then added primes ($'$) to all variables and functions when they pertain to the new equilibrium with $f'_x < f_x$.

Proposition 1. *A decrease in fixed export trade costs forces the least efficient firms to exit and therefore generates productivity improvements in both regions. It also creates the entry of new regular firms into the export markets in both countries.*

For Proof: See Appendix 2.6.3.

Trade liberalization in fixed export costs induces an increase in the industry cutoff productivity levels in both countries and a decrease in regular export levels. Falling export costs f_x drive the least efficient processing exporters out of market $\varphi_s^{*'} > \varphi_s^*$. In particular, a reduction in barriers to trade leads to all surviving Chinese processing exporters incurring revenue and profit losses $r_c^{s'}(\varphi) < r_c^s(\varphi)$. The reduction in profits from the foreign market causes some low-efficient processing exporters that were previously marginal to exit dropping out from industry. As the low-productivity processing exporters exit, resources are reallocated toward higher-productivity firms.

With respect to the non-processing firms, the increased exposure to trade improves the productivity thresholds of serving domestic markets: $\varphi_d^{*'} > \varphi_d^*$ and $\varphi_{df}^{*'} > \varphi_{df}^*$ in both countries. Notably, this causes the least productive Chinese regular firms with productivity levels between φ_d^* and $\varphi_d^{*'}$ to no longer be able to earn positive profits

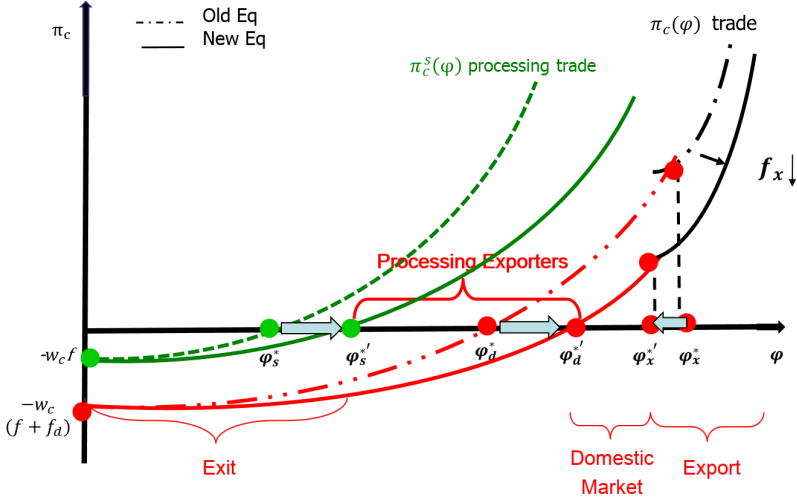


Figure 2.4: The impact of falling f_x on productivity cutoffs in China

in domestic market and hence force them to engage in processing trade. By contrast, the least productive foreign firms ($\varphi_{df}^* \leq \varphi < \varphi_{df}^{*'}$) are forced to exit. Furthermore, all existing domestic regular firms in both regions relinquish a portion of their domestic revenue: $r_i^{d'}(\varphi) < r_i^d(\varphi)$, $i \in \{c, f\}$. On the other hand, the decreased export thresholds (φ_i^x decrease) generate the entry of new firms into the export market. Regular firms which do not export with high f_x are then able to serve the foreign market and their combined sales increase with falling f_x . Firms that already exported prior to the change in f_x not increase their combined revenue and profits. Trade liberalization therefore reallocates revenue and profits away from the least efficient firms that exit toward more productive firms that enter the regular export markets. The reallocations of revenue and profits generate an aggregate productivity improvement and an increase in welfare in both countries. Figure 2.4 graphically represents the changes in productivity cutoffs driven by falling f_x in China.

2.4.2 Decreases in Variable Trade Costs

Proposition 2. *The falling variable trade costs reduce the productivity cutoff of processing exporters and cause the entry of more inefficient firms in China. The regular export cutoff productivity levels decrease as well. By contrast, declining variable costs induce an increase in the domestic cutoff productivity levels in both regions.*

For Proof: See Appendix 2.6.3.

A decrease in the variable trade costs from τ to τ' distributes different effects to Chinese and foreign firms. The evolution of firms in Foreign Country follows the conventional pattern as outlined by Melitz (2003). The least productive foreign firms

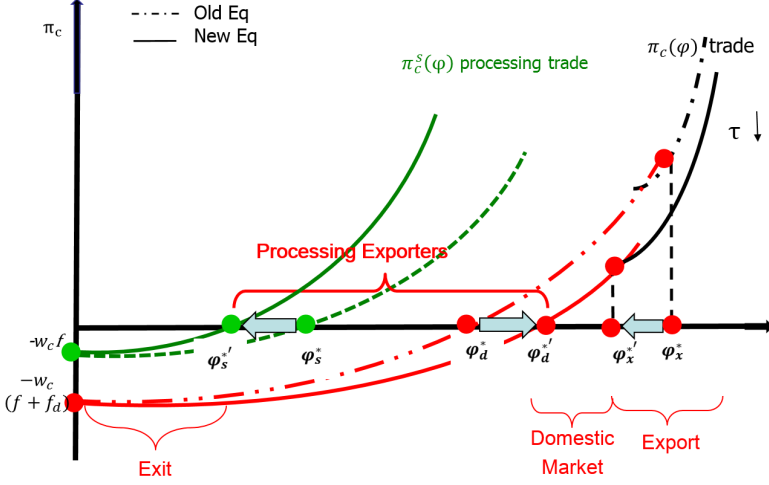


Figure 2.5: The impact of falling τ on productivity cutoffs in China

are forced to exit, and therefore the industrial productivity cutoff level rises $\varphi_{df}' > \varphi_{df}^*$. In contrast, changes in τ shift down the export productivity cutoff level $\varphi_{xf}' < \varphi_{xf}^*$. The increased exposure to trade generates the entry of new regular firms into the export market (that did not export with the higher τ). All firms lose a portion of their domestic sales, so that the firms that do not export incur both a revenue and profit loss. The more productive firms that export more than make up for the loss of domestic sales with increased export sales, and the most productive firms among this group also increase their profits: $r_f^{d'}(\varphi) + r_f^{x'}(\varphi) > r_f^d(\varphi) + r_f^x(\varphi)$.

On the other hand, the decline in variable trade costs distinctly impacts to the processing exporters and non-processing firms in China. Falling iceberg trade costs τ raise the domestic cutoff level: $\varphi_d^{*'} > \varphi_d^*$, and the aggregate domestic productivity in China. Non-exporters previously producing with low productivity levels can no longer earn positive profits from regular production mode, and hence switch into processing trade instead of exiting the industry. Furthermore, it causes the entry of more low-productive processing exporters. That is, the falling transport costs τ particularly benefit them as it creates more export opportunities, offers greater revenues and profits, and pays fewer costs. As shown in Figure 2.5, this leads to more of the low-productive firms self-selecting into processing trade: $\varphi_s^{*'} < \varphi_s^*$. In other words, a fall in transport costs promotes processing activities in China. However, as more Chinese firms become processing exporters, a larger set of varieties produced by Chinese firms with productivity $\varphi \in [\varphi_s^{*'}, \varphi_d^{*'}]$ becomes unavailable to Chinese consumers.

To put it differently, a greater openness raises φ_d^* and thus decreases locally produced varieties. The lower variable trade costs produce an “anti-variety” effect, i.e., the range of consumed variety in China falls as trade becomes freer. By contrast, Foreign

Country experiences a “pro-variety effect”, as more varieties manufactured by Chinese processing exporters become available to foreign consumers. Nevertheless, welfare always increases with trade freeness in both regions, because the increased labor demand (by the less productive firms and new entrants) causes the real wage to increase. It therefore pulls more low-productive non-exporters switching into processing trade, as these firms could not afford to cover the entry costs of the domestic market. In particular, combining the falling variable and fix export costs together help to explain the observed empirical pattern of export booms in China in the 2000s, which are driven by the entry of processing firms into the export market.⁵

2.4.3 Decreases in Domestic Trade Costs

Proposition 3. *The falling domestic trade costs raise the cutoff productivity level of processing exporters in China while decreasing the productivity thresholds of serving the domestic market in both regions. The freer domestic trade also raises the export productivity cutoffs in both countries.*

For Proof: See Appendix 2.6.3.

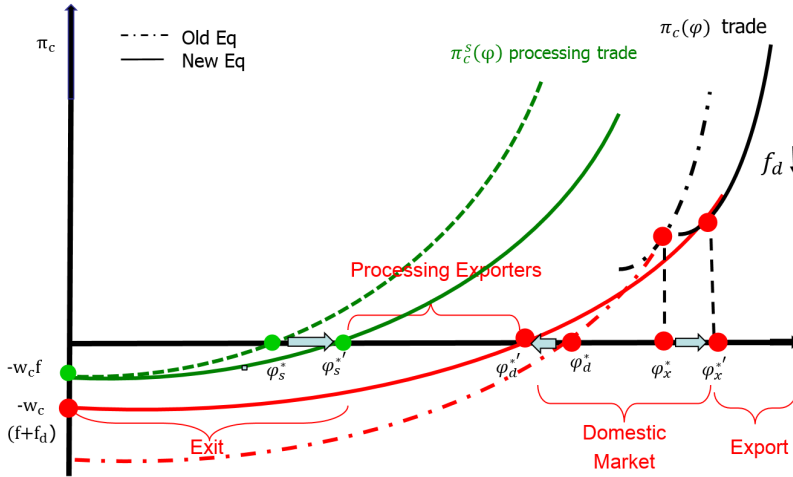


Figure 2.6: The impact of falling f_d on productivity cutoffs in China

Lowering domestic entry costs f_d raise the industry cutoff productivity in China $\varphi_s^{*'} > \varphi_s^*$, and thus forces the least efficient processing exporters to exit. The falling

⁵Documented in Lemoine and Ünal-Kesenci (2004); Yu and Tian (2012); and Manova and Yu (2016), the accession to WTO substantially reduced the average tariff to 9 percent and dramatically increased the prevalence of processing trade in China, in which the share of processing exporters among all exporters increased from 30 percent to 40 percent in 2006 and constituted one-half of China's total trade in the 2000s.

costs of entry into domestic market also force all existing Chinese processing exporters to lose a portion of revenue obtained from Foreign Country: $r_c^{s'}(\varphi) < r_c^s(\varphi)$, $\forall \in \varphi[\varphi_s^*, \varphi_d^*)$. Conversely, falling domestic trade barriers decrease the domestic cutoff productivity levels in both countries. In particular, the declines in domestic trade costs in China substantially reduce the barriers of serving domestic market, which create the entry of new domestic firms. The previously relative efficient processing exporters that were not able to pursue regular production mode are capable of engaging in domestic trade with lower f_d . Also, these new domestic producers benefit from the more integrated domestic market as their revenue and profits increase. However, the successful entry of less productive processing exporters into the domestic market contributes to an aggregate domestic productivity loss. Moreover, the factors of increased industry cutoff productivity level and decreased domestic productivity threshold in China indicate that more Chinese firms are operating in regular production mode, and thus the competition in the domestic market is intensified. By contrast, as fewer Chinese firms engage in processing trade, fewer varieties are manufactured by Chinese processing exporters, which result in fewer varieties being supplied to foreign consumers.

Another way to gain insight into the impact of falling domestic barriers comes from the consumption side. A falling in domestic costs decreases the domestic cutoff productivity levels and therefore reduces the average profits of existing regular firms in both regions. The lower profit levels, in turn, imply an increase in domestic variety. The increasing product variety and the decreasing aggregate domestic productivity oppositely affects welfare. The appendix 2.6.3 shows that the welfare change is positive, and hence that the expanding product variety effect dominates that of the lower aggregate domestic productivity levels. This yields the reasonable property: lower domestic trade costs have an overall positive impact on welfare. In other words, if the domestic impediments were to hasten, it could alleviate China's reliance on processing trade and help China to avoid sticking in the low value-added chain. Figure 2.6 visualizes the effects of trade liberalization in f_d on the cutoff productivity levels of all types of firms in China.

On the other hand, the decrease from f_d to f_d' induces an increase in the cutoff productivity levels of regular exporters $(\varphi_c^x, \varphi_f^x \uparrow)$ ⁶. The more intense entry following the decreased domestic productivity thresholds in both countries enhances domestic

⁶Melitz (2003) states that there is a transitional issue associated with the exporting status of firms with productivity level between φ_c^x and $\varphi_c^{x'}$. The loss of export sales to counterpart (from $r_c^x(\varphi)$ down to the $r_c^{x'}(\varphi)$) is such that firms entering with productivity levels between φ_c^x and $\varphi_c^{x'}$ will not export as the lower variable profit $\frac{r_c^{x'}(\varphi)}{\sigma}$ no longer covers the amortized portion of the entry costs f_x . On the other hand, incumbent firms with productivity level in this range have already incurred the sunk entry costs of export and have no reason to exit the export market until they are hit with the bad shock and exit the industry. Eventually, all these incumbent firms exit and no firm with a productivity level in that range will export once the new steady state equilibrium is attained.

product market competition and therefore raises the export productivity levels. That is, the productivity of survival is lowered while the export cutoff increases when the domestic market becomes more integrated.

The falling domestic trade costs deliver profound policy implications to China. Empirical evidence (Naughton, 2003; Wong, 2012) have documented that China has a very segmented domestic market; domestic firms incur barriers to serve local markets. Some other studies have demonstrated that the internal market fragmentation promotes China's trade performance. Less efficient Chinese firms, which are not able to overcome such costs, engage in processing trade and serve the foreign countries. That is, processing exporters enter the international market as an alternative way to survive. The factors of the severe fragmented Chinese market and the pervasive of processing trade distort firm export behavior, which not only generate a large number of processing exporters but also contribute to the rapid expansion of China's export.

The highly fragmented domestic market has led to many Chinese firms only engaging in processing trade and getting supplied original equipment manufacturing products for the global buyers. Nevertheless, they fail to establish a position in the international market for innovative and high value-added products. Although local protection measures may help to lift local economies in the short term, the distorted national market has spawned problems such as higher operation costs and overcapacity in the wider economy, undermining the economies of scale of China's huge market. Consequently, clearing domestic market barriers, coupled with reducing export reliance on processing trade, could allow the most productive ones to thrive, facilitate technology diffusion, improve productivity and ultimately increase the competitiveness of firms and growth in China. To this end, the model offers a theoretical basis for constructing an integrated Chinese domestic market. In particular, building a unified and open market system can allow productivity to play a decisive role in allocating resources, and hence bring aggregate productivity growth when facing trade liberalization. Furthermore, the results and intuitions presented here indicate that gains from more liberalized trade could be larger for the more integrated internal market. This implies that China would respond to more export opportunities resulting from falling trade barriers if the government can unify the domestic market and liberalize domestic trade. The sooner a well-developed modern market system is established, the higher the aggregate productivity would likely be, and the smoother the transition.

2.5 Conclusion

Firm-level export patterns in China are different from those in developed countries and they may seem to be at odds with existing literature. Nevertheless, this can

be explained by isolating processing trade from the regular export in the context of heterogeneous firms model. This paper therefore incorporates processing exporters into a single sector of Melitz (2003) model to explain how the pattern of trade in China is determined by the interaction of trade barriers and processing trade. This model captures the existence of processing exporters and explains their inferior productivity levels. It also shows how trade liberalization affects the aggregate productivity, welfare and export performances of Chinese firms.

In other words, this paper has described and analyzed a fundamental issue of co-existence, even within the same industry of exporters, processing exporters, and non-exporters. The paper shows how the presence of processing trade alongside the domestic trade costs drastically affect how the impact of trade is distributed across different types of firms. The less efficient firms behave as processing exporters, the moderate productive firms concentrate on the domestic market while the most efficient ones benefit from trade in revenues and profits. More importantly, the analysis reveals that increases in a country's exposure to trade unequivocally engender welfare gains. However, the domestic market distortion could impede firm performance and hinder the aggregate productivity improvement. Furthermore, the model highlights that trade-induced reallocation effect of export which may generate aggregate productivity growth does not work effectively in industries where processing trade is pervasive.

The recognition of the nature of firm heterogeneity is important because it will generate new insights concerning the current trade pattern and growth. Exporting is especially considered as an engine of growth in China. Processing trade indeed has a significant positive effect on labor employment and it substantially utilizes China's comparative advantage in labor-intensive products. However, the long-run benefits associated with trade still depends on the productivity. It is therefore imperative to have a model that can look into the costs and benefits of export processing and predict the impact of trade policies on various types of firms. Consequently, a deeper understanding of the factors that drive firms' export success will facilitate the design of policies that promote trade and ultimately growth in China. Interesting areas for future research include investigating the impact of trade liberalization on foreign-owned, private firms and state-own enterprises separately and empirically testing of my model's theoretical predictions. Also, further quantitative analysis of the effect of trade liberalization on wages and welfare in both China and other countries would be interesting.

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2.6 Appendix

2.6.1 Equilibrium Conditions

Derivation of Average Revenue

Average revenue of a Chinese firm can be determined as follows:

$$\begin{aligned}
\bar{r}_c &= p_c^s r_c^s(\tilde{\varphi}_c^s) + p_c^d(r_c^d(\tilde{\varphi}_c^d) + p_c^x r_c^x(\tilde{\varphi}_c^x)) \\
&= p_c^s \int_{\varphi_s^*}^{\varphi_d^*} \frac{r_c^s(\varphi)g(\varphi)}{G(\varphi_d^*) - G(\varphi_s^*)} d\varphi + p_c^d \left(\int_{\varphi_d^*}^{\infty} \frac{r_c^d(\varphi)g(\varphi)}{1 - G(\varphi_d^*)} d\varphi + p_c^x \int_{\varphi_x^*}^{\infty} \frac{r_c^x(\varphi)g(\varphi)}{1 - G(\varphi_x^*)} d\varphi \right) \\
&= p_c^s \int_{\varphi_s^*}^{\varphi_d^*} \sigma f w_c \left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} \frac{g(\varphi)}{G(\varphi_d^*) - G(\varphi_s^*)} d\varphi \\
&\quad + p_c^d \left(\int_{\varphi_d^*}^{\infty} \sigma(f + f_d) w_c \left(\frac{\varphi}{\varphi_d^*} \right)^{\sigma-1} \frac{g(\varphi)}{1 - G(\varphi_d^*)} d\varphi + p_c^x \int_{\varphi_x^*}^{\infty} \sigma f_x w_c \left(\frac{\varphi}{\varphi_x^*} \right)^{\sigma-1} \frac{g(\varphi)}{1 - G(\varphi_x^*)} d\varphi \right) \\
&= p_c^s \sigma f w_c \left(\frac{1}{\varphi_s^*} \right)^{\sigma-1} \underbrace{\int_{\varphi_s^*}^{\varphi_d^*} \frac{\varphi^{\sigma-1} g(\varphi)}{G(\varphi_d^*) - G(\varphi_s^*)} d\varphi}_{(\tilde{\varphi}_c^s)^{\sigma-1}} \\
&\quad + p_c^d \sigma w_c \left((f + f_d) \left(\frac{1}{\varphi_d^*} \right)^{\sigma-1} \underbrace{\int_{\varphi_d^*}^{\infty} \frac{\varphi^{\sigma-1} g(\varphi)}{1 - G(\varphi_d^*)} d\varphi}_{(\tilde{\varphi}_c^d)^{\sigma-1}} + p_c^x f_x \left(\frac{1}{\varphi_x^*} \right)^{\sigma-1} \underbrace{\int_{\varphi_x^*}^{\infty} \frac{\varphi^{\sigma-1} g(\varphi)}{1 - G(\varphi_x^*)} d\varphi}_{(\tilde{\varphi}_c^x)^{\sigma-1}} \right) \\
&= p_c^s \sigma f w_c \left(\frac{\tilde{\varphi}_c^s}{\varphi_s^*} \right)^{\sigma-1} + p_c^d \sigma w_c \left[(f + f_d) \left(\frac{\tilde{\varphi}_c^d}{\varphi_d^*} \right)^{\sigma-1} + p_c^x f_x \left(\frac{\tilde{\varphi}_c^x}{\varphi_x^*} \right)^{\sigma-1} \right], \tag{2.18}
\end{aligned}$$

which depends solely on the productivity cutoffs, φ_s^* , φ_d^* and φ_x^* , and parameters. The average revenue of a foreign firm can be derived as the similar way

$$\bar{r}_f = \sigma(f + f_d) w_f \left(\frac{\tilde{\varphi}_f^d}{\varphi_{df}^*} \right)^{\sigma-1} + p_f^x \sigma f_x w_f \left(\frac{\tilde{\varphi}_f^x}{\varphi_{xf}^*} \right)^{\sigma-1}. \tag{2.19}$$

Derivation of Free Entry Conditions

Combining the ZCP1 and FE1, and use the definition of aggregate average productivity from 2.11-2.13, we obtain a single equation that determines the productivity cutoff in China

$$\begin{aligned}
f_e w_c &= \frac{1 - G(\varphi_s^*)}{\delta} \left\{ p_c^s \pi_c^s(\tilde{\varphi}_c^s) + p_c^d(\pi_c^d(\tilde{\varphi}_c^d) + p_c^x \pi_c^x(\tilde{\varphi}_c^x)) \right\} \\
&= \frac{1 - G(\varphi_s^*)}{\delta} w_c \left\{ p_c^s f \left[\left(\frac{\tilde{\varphi}_c^s}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] \right. \\
&\quad \left. + p_c^d \left((f + f_d) \left[\left(\frac{\tilde{\varphi}_c^d}{\varphi_d^*} \right)^{\sigma-1} - 1 \right] + p_c^x f_x \left[\left(\frac{\tilde{\varphi}_c^x}{\varphi_x^*} \right)^{\sigma-1} - 1 \right] \right) \right\}
\end{aligned}$$

wage w_c cancel out from both sides

$$\begin{aligned}
f_e &= \frac{1 - G(\varphi_s^*)}{\delta} \frac{G(\varphi_d^*) - G(\varphi_s^*)}{1 - G(\varphi_s^*)} f \left[\left(\frac{\tilde{\varphi}_c^s}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] \\
&+ \frac{1 - G(\varphi_s^*)}{\delta} \frac{1 - G(\varphi_d^*)}{1 - G(\varphi_s^*)} (f + f_d) \left[\left(\frac{\tilde{\varphi}_c^d}{\varphi_d^*} \right)^{\sigma-1} - 1 \right] \\
&+ \frac{1 - G(\varphi_s^*)}{\delta} \frac{1 - G(\varphi_d^*)}{1 - G(\varphi_s^*)} \frac{1 - G(\varphi_x^*)}{1 - G(\varphi_d^*)} f \left[\left(\frac{\tilde{\varphi}_c^x}{\varphi_x^*} \right)^{\sigma-1} - 1 \right] \\
&= \frac{f}{\delta} (G(\varphi_d^*) - G(\varphi_s^*)) \tilde{\varphi}_c^{s\sigma-1} \tilde{\varphi}_s^{*1-\sigma} - \frac{f}{\delta} (G(\varphi_d^*) - G(\varphi_s^*)) \\
&+ \frac{f + f_d}{\delta} (1 - G(\varphi_d^*)) \tilde{\varphi}_c^{d\sigma-1} \tilde{\varphi}_d^{*1-\sigma} - \frac{f + f_d}{\delta} (1 - G(\varphi_d^*)) \\
&+ \frac{f_x}{\delta} (1 - G(\varphi_x^*)) \tilde{\varphi}_c^{x\sigma-1} \tilde{\varphi}_x^{*1-\sigma} - \frac{f_x}{\delta} (1 - G(\varphi_x^*)) \\
&= \frac{f}{\delta} (G(\varphi_d^*) - G(\varphi_s^*)) \varphi_s^{*1-\sigma} \frac{1}{G(\varphi_d^*) - G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f}{\delta} \int_{\varphi_s^*}^{\varphi_d^*} g(\varphi) d\varphi \\
&+ \frac{f + f_d}{\delta} (1 - G(\varphi_d^*)) \varphi_d^{*1-\sigma} \frac{1}{1 - G(\varphi_d^*)} \int_{\varphi_d^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f + f_d}{\delta} \int_{\varphi_d^*}^{\infty} g(\varphi) d\varphi \\
&+ \frac{f_x}{\delta} (1 - G(\varphi_x^*)) \varphi_x^{*1-\sigma} \frac{1}{1 - G(\varphi_x^*)} \int_{\varphi_x^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f_x}{\delta} \int_{\varphi_x^*}^{\infty} g(\varphi) d\varphi \\
&= \frac{f}{\delta} \int_{\varphi_s^*}^{\varphi_d^*} \varphi_s^{*1-\sigma} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f}{\delta} \int_{\varphi_s^*}^{\varphi_d^*} g(\varphi) d\varphi \\
&+ \frac{f + f_d}{\delta} \int_{\varphi_d^*}^{\infty} \varphi_d^{*1-\sigma} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f + f_d}{\delta} \int_{\varphi_d^*}^{\infty} g(\varphi) d\varphi \\
&+ \frac{f_x}{\delta} \int_{\varphi_x^*}^{\infty} \varphi_x^{*1-\sigma} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f_x}{\delta} \int_{\varphi_x^*}^{\infty} g(\varphi) d\varphi \\
&= \frac{f}{\delta} \int_{\varphi_s^*}^{\varphi_d^*} \left[\left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi + \frac{f + f_d}{\delta} \int_{\varphi_d^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_d^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\
&\quad + \frac{f_x}{\delta} \int_{\varphi_x^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_x^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\
&= \frac{f}{\delta} J(\varphi_s^*) + \frac{f + f_d}{\delta} J(\varphi_d^*) + \frac{f_x}{\delta} J(\varphi_x^*), \tag{2.23}
\end{aligned}$$

where

$$\begin{aligned}
J(\varphi_s^*) &= \int_{\varphi_s^*}^{\varphi_d^*} \left[\left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi, \\
J(\varphi_d^*) &= \int_{\varphi_d^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_d^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi, \\
J(\varphi_x^*) &= \int_{\varphi_x^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_x^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi.
\end{aligned}$$

Similarly, combining the ZCP2 and FE2, and use the definition of aggregate average productivity from 2.16-2.17, we obtain a single equation that determines the produc-

tivity cutoff in Foreign Country

$$\begin{aligned} f_e w_f &= \frac{1 - G(\varphi_{df}^*)}{\delta} \left\{ \pi_f^d(\tilde{\varphi}_f^d) + p_f^x \pi_f^x(\tilde{\varphi}_f^x) \right\} \\ &= \frac{1 - G(\varphi_{df}^*)}{\delta} w_f \left\{ (f + f_d) \left[\left(\frac{\tilde{\varphi}_f^d}{\varphi_{df}^*} \right)^{\sigma-1} - 1 \right] + p_f^x f_x \left[\left(\frac{\tilde{\varphi}_f^x}{\varphi_{xf}^*} \right)^{\sigma-1} - 1 \right] \right\} \end{aligned}$$

wage w_f cancel out from both sides

$$\begin{aligned} f_e &= \frac{1 - G(\varphi_{df}^*)}{\delta} (f + f_d) (\varphi_{df}^*)^{1-\sigma} (\tilde{\varphi}_f^d)^{\sigma-1} - \frac{f + f_d}{\delta} (1 - G(\varphi_{df}^*)) \\ &\quad + \frac{1 - G(\varphi_{df}^*)}{\delta} \frac{1 - G(\varphi_{xf}^*)}{1 - G(\varphi_{df}^*)} f_x \left[\left(\frac{\tilde{\varphi}_f^x}{\varphi_{xf}^*} \right)^{\sigma-1} - 1 \right] \\ &= \frac{f + f_d}{\delta} (1 - G(\varphi_{df}^*)) (\varphi_{df}^*)^{1-\sigma} \frac{1}{1 - G(\varphi_{df}^*)} \int_{\varphi_{df}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f + f_d}{\delta} \int_{\varphi_{df}^*}^{\infty} g(\varphi) d\varphi \\ &\quad + \frac{f_x}{\delta} (1 - G(\varphi_{xf}^*)) (\varphi_{xf}^*)^{1-\sigma} (\tilde{\varphi}_f^x)^{\sigma-1} - \frac{f_x}{\delta} (1 - G(\varphi_{xf}^*)) \\ &= \frac{f + f_d}{\delta} \int_{\varphi_{df}^*}^{\infty} \left(\frac{\varphi}{\varphi_{df}^*} \right)^{\sigma-1} g(\varphi) d\varphi - \frac{f + f_d}{\delta} \int_{\varphi_{df}^*}^{\infty} g(\varphi) d\varphi \\ &\quad + \frac{f_x}{\delta} (1 - G(\varphi_{xf}^*)) (\varphi_{xf}^*)^{1-\sigma} \frac{1}{1 - G(\varphi_{xf}^*)} \int_{\varphi_{xf}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi - \frac{f_x}{\delta} \int_{\varphi_{xf}^*}^{\infty} g(\varphi) d\varphi \\ &= \frac{f + f_d}{\delta} \int_{\varphi_{df}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{df}^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi + \frac{f_x}{\delta} \int_{\varphi_{xf}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{xf}^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\ &= \frac{f + f_d}{\delta} J(\varphi_{df}^*) + \frac{f_x}{\delta} J(\varphi_{xf}^*), \tag{2.24} \end{aligned}$$

where

$$\begin{aligned} J(\varphi_{df}^*) &= \int_{\varphi_{df}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{df}^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\ J(\varphi_{xf}^*) &= \int_{\varphi_{xf}^*}^{\infty} \left[\left(\frac{\varphi}{\varphi_{xf}^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi. \end{aligned}$$

2.6.2 Determination of the Equilibrium

Derivation of Price Indices

Using the equilibrium pricing rules, domestic cutoff productivity in China, foreign exporting productivity threshold, and the *ex post* productivity distributions from both countries, we obtain the price index in China:

$$\begin{aligned} P_c^{1-\sigma} &= \int_0^{\infty} p_c^d(\varphi)^{1-\sigma} M_c^d \mu_c^d(\varphi) d\varphi + \int_0^{\infty} p_f^x(\varphi)^{1-\sigma} M_f^x \mu_f^x(\varphi) d\varphi \\ &= \int_{\varphi_d^*}^{\infty} p_c^d(\varphi)^{1-\sigma} M_c^d \frac{g(\varphi)}{1 - G(\varphi_d^*)} d\varphi + \int_{\varphi_{xf}^*}^{\infty} p_f^x(\varphi)^{1-\sigma} M_f^x \frac{g(\varphi)}{1 - G(\varphi_{xf}^*)} d\varphi \\ &= \frac{M_c^d}{1 - G(\varphi_d^*)} \int_{\varphi_d^*}^{\infty} \left(\frac{1}{\rho\varphi} \right)^{1-\sigma} g(\varphi) d\varphi + \frac{M_f^x}{1 - G(\varphi_{xf}^*)} \int_{\varphi_{xf}^*}^{\infty} \left(\frac{\tau}{\rho\varphi} \right)^{1-\sigma} g(\varphi) d\varphi \end{aligned}$$

$$\begin{aligned}
&= M_c^d \left(\frac{w_c}{\rho} \right)^{1-\sigma} \frac{1}{1 - G(\varphi_d^*)} \int_{\varphi_d^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&+ M_f^x \left(\frac{\tau w_f}{\rho} \right)^{1-\sigma} \frac{1}{1 - G(\varphi_{xf}^*)} \int_{\varphi_{xf}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&= M_c^d \left(\frac{w_c}{\rho} \right)^{1-\sigma} \tilde{\varphi}_c^{d^{\sigma-1}} + M_f^x \left(\frac{\tau w_f}{\rho} \right)^{1-\sigma} \tilde{\varphi}_f^{x^{\sigma-1}} \\
&= M_c^d p_c^d (\tilde{\varphi}_c^d)^{1-\sigma} + M_f^x p_f^x (\tilde{\varphi}_f^x)^{1-\sigma} \\
P_c &= \left[M_c^d p_c^d (\tilde{\varphi}_c^d)^{1-\sigma} + M_f^x p_f^x (\tilde{\varphi}_f^x)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}
\end{aligned} \tag{2.25}$$

Analogously, using the equilibrium pricing rules, zero profit productivity cutoff in Foreign Country, processing and regular export productivity cutoff levels of Chinese firms, and the *ex post* productivity distributions from both countries, the price index in Foreign Country is obtained:

$$\begin{aligned}
P_f^{1-\sigma} &= \int_0^{\infty} p_f^d(\varphi)^{1-\sigma} M_f \mu_f(\varphi) d\varphi + \int_0^{\infty} p_c^x(\varphi)^{1-\sigma} M_c^x \mu_c^x(\varphi) d\varphi \\
&+ \int_0^{\infty} p_c^s(\varphi)^{1-\sigma} M_c^s \mu_c^s(\varphi) d\varphi \\
&= \int_{\varphi_{df}^*}^{\infty} p_f^d(\varphi)^{1-\sigma} M_f \frac{g(\varphi)}{1 - G(\varphi_{df}^*)} d\varphi + \int_{\varphi_x^*}^{\infty} p_c^x(\varphi)^{1-\sigma} M_c^f \frac{g(\varphi)}{1 - G(\varphi_x^*)} d\varphi \\
&+ \int_{\varphi_s^*}^{\varphi_d^*} p_c^s(\varphi)^{1-\sigma} M_c^s \frac{g(\varphi)}{G(\varphi_d^*) - G(\varphi_s^*)} d\varphi \\
&= M_f \left(\frac{w_f}{\rho} \right)^{1-\sigma} \frac{1}{1 - G(\varphi_{df}^*)} \int_{\varphi_{df}^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&+ M_c^x \left(\frac{\tau w_c}{\rho} \right)^{1-\sigma} \frac{1}{1 - G(\varphi_x^*)} \int_{\varphi_x^*}^{\infty} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&+ M_c^s \left(\frac{\tau w_c}{\rho} \right)^{1-\sigma} \frac{1}{G(\varphi_d^*) - G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&= M_f \left(\frac{w_f}{\rho} \right)^{1-\sigma} \tilde{\varphi}_f^{d^{\sigma-1}} + M_c^x \left(\frac{\tau w_c}{\rho} \right)^{1-\sigma} \tilde{\varphi}_c^{x^{\sigma-1}} + M_c^s \left(\frac{\tau w_c}{\rho} \right)^{1-\sigma} \tilde{\varphi}_c^{s^{\sigma-1}} \\
&= M_f \left(\frac{w_f}{\rho \tilde{\varphi}_f^d} \right)^{1-\sigma} + M_c^x \left(\frac{\tau w_c}{\rho \tilde{\varphi}_c^x} \right)^{1-\sigma} + M_c^s \left(\frac{\tau w_c}{\rho \tilde{\varphi}_c^s} \right)^{1-\sigma} \\
&= M_f p_f^d (\tilde{\varphi}_f^d)^{1-\sigma} + M_c^x p_c^x (\tilde{\varphi}_c^x)^{1-\sigma} + M_c^s p_c^s (\tilde{\varphi}_c^s)^{1-\sigma} \\
P_f &= \left[M_f p_f^d (\tilde{\varphi}_f^d)^{1-\sigma} + M_c^x p_c^x (\tilde{\varphi}_c^x)^{1-\sigma} + M_c^s p_c^s (\tilde{\varphi}_c^s)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}
\end{aligned} \tag{2.26}$$

Trade Balance Trade

Balanced trade condition implies the representative agents in both countries each satisfying their respective budget constraint. It can be explicitly written as:

$$\int r_c^x M_c^x \mu_c^x(\varphi) d\varphi + \int r_c^s M_c^s \mu_c^s(\varphi) d\varphi = \int r_f^x M_f^x \mu_f^x(\varphi) d\varphi$$

$$\begin{aligned}
& \int_0^\infty (w_c \tau)^{1-\sigma} R_f(P_f \rho \varphi)^{\sigma-1} M_c^x \mu_c^x(\varphi) d\varphi + \int_0^\infty (w_c \tau)^{1-\sigma} R_f(P_f \rho \varphi)^{\sigma-1} M_c^s \mu_c^s(\varphi) d\varphi \\
&= \int_0^\infty (w_f \tau)^{1-\sigma} R_c(P_c \rho \varphi)^{\sigma-1} M_f^x \mu_f^x(\varphi) d\varphi \\
& (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^x \int_{\varphi_x^*}^\infty \varphi^{\sigma-1} \frac{g(\varphi)}{1-G(\varphi_x^*)} d\varphi \\
&+ (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^s \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} \frac{g(\varphi)}{G(\varphi_d^*)-G(\varphi_s^*)} d\varphi \\
&= (w_f \tau)^{1-\sigma} R_c(P_c \rho)^{\sigma-1} M_f^x \int_{\varphi_{xf}^*}^\infty \varphi^{\sigma-1} \frac{g(\varphi)}{1-G(\varphi_{xf}^*)} d\varphi \\
& (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^x \frac{1}{1-G(\varphi_x^*)} \int_{\varphi_x^*}^\infty \varphi^{\sigma-1} g(\varphi) d\varphi \\
&+ (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^s \frac{1}{G(\varphi_d^*)-G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&= (w_f \tau)^{1-\sigma} R_c(P_c \rho)^{\sigma-1} M_f^x \frac{1}{1-G(\varphi_{xf}^*)} \int_{\varphi_{xf}^*}^\infty \varphi^{\sigma-1} g(\varphi) d\varphi \\
& (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^x \tilde{\varphi}_c^{x\sigma-1} + (w_c \tau)^{1-\sigma} R_f(P_f \rho)^{\sigma-1} M_c^s \tilde{\varphi}_c^{s\sigma-1} \\
&= (w_f \tau)^{1-\sigma} R_c(P_c \rho)^{\sigma-1} M_f^x \tilde{\varphi}_f^{x\sigma-1} \\
& (w_c \tau)^{1-\sigma} R_f(P_f \rho \tilde{\varphi}_c^x)^{\sigma-1} M_c^x + (w_c \tau)^{1-\sigma} R_f(P_f \rho \tilde{\varphi}_c^s)^{\sigma-1} M_c^s \\
&= (w_f \tau)^{1-\sigma} R_c(P_c \rho \tilde{\varphi}_f^x)^{\sigma-1} M_f^x \\
& r_c^f(\tilde{\varphi}_c^x) M_c^x + r_c^s(\tilde{\varphi}_c^s) M_c^s = r_f^x(\tilde{\varphi}_f^x) M_f^x
\end{aligned} \tag{2.29}$$

Existence and Uniqueness of the Equilibrium Cutoff Level

With asymmetric countries, the steady-state industry equilibrium can be referenced by a vector of variables $\{\varphi_s^*, \varphi_d^*, \varphi_x^*, \varphi_{df}^*, \varphi_{xf}^*, R_c, R_f, P_c, P_f\}$, in terms of which all other endogenous variable can be written. First, we repeat the free entry conditions

$$f_e = \frac{f}{\delta} J(\varphi_s^*) + \frac{f + f_d}{\delta} J(\varphi_d^*) + \frac{f_x}{\delta} J(\varphi_x^*), \tag{2.23}$$

$$f_e = \frac{f + f_d}{\delta} J(\varphi_{df}^*) + \frac{f_x}{\delta} J(\varphi_{xf}^*), \tag{2.24}$$

where $\varphi_s^* = \varphi_d^* \tau \left(\frac{f}{f+f_d} \right)^{\frac{1}{\sigma-1}}$, $\varphi_x^* = \varphi_d^* \tau \left(\frac{f_x}{f+f_d} \right)^{\frac{1}{\sigma-1}}$ are implicit defined as a function of φ_d^* ; and $\varphi_{xf}^* = \varphi_{df}^* \tau \left(\frac{f_x}{f+f_d} \right)^{\frac{1}{\sigma-1}}$ is defined a function of φ_{df}^* .

Proof $J(\varphi)$ is decreasing function on $(0, +\infty)$

For processing exporters, we have

$$\begin{aligned}
J(\varphi_s^*) &= \int_{\varphi_s^*}^{\varphi_d^*} \left[\left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] g(\varphi) d\varphi \\
&= \int_{\varphi_s^*}^{\varphi_d^*} \left(\frac{\varphi}{\varphi_s^*} \right)^{\sigma-1} g(\varphi) d\varphi - \int_{\varphi_s^*}^{\varphi_d^*} g(\varphi) d\varphi
\end{aligned}$$

$$\begin{aligned}
&= \varphi_s^{*1-\sigma} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi - [G(\varphi_d^*) - G(\varphi_s^*)] \\
&= \varphi_s^{*1-\sigma} (\tilde{\varphi}_c^s)^{\sigma-1} [G(\varphi_d^*) - G(\varphi_s^*)] - [G(\varphi_d^*) - G(\varphi_s^*)] \\
&= [G(\varphi_d^*) - G(\varphi_s^*)] \left[\left(\frac{\tilde{\varphi}_c^s}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] \\
&= [G(\varphi_d^*) - G(\varphi_s^*)] k(\varphi_s^*)
\end{aligned} \tag{2.30}$$

Recall that $k(\varphi_s^*)$ is defined as

$$k(\varphi_s^*) = (\varphi_s^*)^{1-\sigma} \frac{1}{G(\varphi_d^*) - G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi - 1. \tag{2.31}$$

Differentiating (2.31) with respect to φ_s^* yields:

$$\begin{aligned}
k'(\varphi_s^*) &= \frac{g(\varphi_s^*)}{[G(\varphi_d^*) - G(\varphi_s^*)]^2} (\varphi_s^*)^{1-\sigma} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi \\
&\quad + \frac{(\varphi_s^*)^{1-\sigma}}{G(\varphi_d^*) - G(\varphi_s^*)} [-(\varphi_s^*)^{\sigma-1} g(\varphi_s^*)] \\
&\quad + (1-\sigma)(\varphi_s^*)^{-1} \left[\frac{\tilde{\varphi}_c^s(\varphi_s^*)}{\varphi_s^*} \right]^{\sigma-1} \\
&= \frac{g(\varphi_s^*)(\varphi_s^*)^{1-\sigma}}{G(\varphi_d^*) - G(\varphi_s^*)} \underbrace{\frac{1}{G(\varphi_d^*) - G(\varphi_s^*)} \int_{\varphi_s^*}^{\varphi_d^*} \varphi^{\sigma-1} g(\varphi) d\varphi}_{(\tilde{\varphi}_c^s)^{\sigma-1}} \\
&\quad - \frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} + \frac{\sigma-1}{\varphi_s^*} \left[\frac{\tilde{\varphi}_c^s(\varphi_s^*)}{\varphi_s^*} \right]^{\sigma-1} \\
&= \frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} \left(\frac{\tilde{\varphi}_c^s(\varphi_s^*)}{\varphi_s^*} \right)^{\sigma-1} - \frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} - \frac{\sigma-1}{\varphi_s^*} \left(\frac{\tilde{\varphi}_c^s(\varphi_s^*)}{\varphi_s^*} \right)^{\sigma-1} \\
&= \frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} \left[\left(\frac{\tilde{\varphi}_c^s(\varphi_s^*)}{\varphi_s^*} \right)^{\sigma-1} - 1 \right] - \frac{\sigma-1}{\varphi_s^*} (k(\varphi_s^*) + 1) \\
&= \frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} k(\varphi_s^*) - \frac{\sigma-1}{\varphi_s^*} (k(\varphi_s^*) + 1)
\end{aligned}$$

We have defined $J(\varphi_s^*) = [G(\varphi_d^*) - G(\varphi_s^*)]k(\varphi_s^*)$, then its derivative and elasticity is given by:

$$\begin{aligned}
J'(\varphi_s^*) &= -g'(\varphi_s^*)k(\varphi_s^*) + (G(\varphi_d^*) - G(\varphi_s^*))k'(\varphi_s^*) \\
&= -g'(\varphi_s^*)k(\varphi_s^*) + (G(\varphi_d^*) \\
&\quad - G(\varphi_s^*)) \left[\frac{g(\varphi_s^*)}{G(\varphi_d^*) - G(\varphi_s^*)} k(\varphi_s^*) - \frac{\sigma-1}{\varphi_s^*} (k(\varphi_s^*) + 1) \right] \\
&= -\frac{1}{\varphi_s^*} (\sigma-1) (G(\varphi_d^*) - G(\varphi_s^*)) (k(\varphi_s^*) + 1) < 0.
\end{aligned} \tag{2.32}$$

$$\begin{aligned}\frac{J'(\varphi_s^*)\varphi_s^*}{J(\varphi_s^*)} &= \frac{\frac{1}{\varphi_s^*}\varphi_s^*(\sigma-1)(G(\varphi_d^*)-G(\varphi_s^*))(k(\varphi_s^*)+1)}{[G(\varphi_d^*)-G(\varphi_s^*)]k(\varphi_s^*)} \\ &= -(\sigma-1)\left(1+\frac{1}{k(\varphi_s^*)}\right) < -(\sigma-1).\end{aligned}\quad (2.33)$$

For the rest types of firms, we proceed our proof as follows:⁷ recall that $k(\varphi) = \left(\frac{\tilde{\varphi}(\varphi)}{\varphi}\right)^{\sigma-1} - 1$ where the aggregate productivities of all other types firms are defined as:

$$\tilde{\varphi}(\varphi)^{\sigma-1} = \frac{1}{1-G(\varphi)} \int_{\varphi}^{\infty} \xi^{\sigma-1} g(\xi) d\xi \quad (2.34)$$

Differentiating (2.34) with respect to φ yields:

$$\frac{\partial \tilde{\varphi}(\varphi)^{\sigma-1}}{\partial \varphi} = \frac{g(\varphi)}{1-G(\varphi)} [\tilde{\varphi}(\varphi)^{\sigma-1} - \varphi^{\sigma-1}]$$

Therefore

$$\begin{aligned}k'(\varphi) &= \frac{g(\varphi)}{1-G(\varphi)} \left[\left(\frac{\tilde{\varphi}(\varphi)}{\varphi} \right)^{\sigma-1} - 1 \right] - \left(\frac{\tilde{\varphi}(\varphi)}{\varphi} \right)^{\sigma-1} \frac{\sigma-1}{\varphi} \\ &= \frac{k(\varphi)g(\varphi)}{1-G(\varphi)} - \frac{(\sigma-1)[k(\varphi)+1]}{\varphi} \\ &= \frac{k(\varphi)g(\varphi)\varphi - (\sigma-1)[k(\varphi)+1](1-G(\varphi))}{(1-G(\varphi))\varphi}\end{aligned}$$

We have defined $J(\varphi) = [1-G(\varphi)]k(\varphi)$, then its derivative and elasticity are given by:

$$J'(\varphi) = -\frac{1}{\varphi}(\sigma-1)[k(\varphi)+1](1-G(\varphi)) < 0, \quad (2.35)$$

$$\frac{J'(\varphi)\varphi}{J(\varphi)} = -(\sigma-1)\left(1+\frac{1}{k(\varphi)}\right) < -(\sigma-1). \quad (2.36)$$

Therefore, we have proved $J(\varphi)$ is non-negative and its elasticity with respect to φ is negative and bounded away from zero, $J(\varphi)$ must be decreasing to zero as φ goes to infinity. Furthermore, $\lim_{\varphi \rightarrow 0} J(\varphi) = \infty$ since $\lim_{\varphi \rightarrow 0} k(\varphi) = \infty$. Thus, $J(\varphi) = [1-G(\varphi)]k(\varphi)$ decreases from infinity to zero on $(0, \infty)$; $\frac{\partial \varphi_s^*}{\partial \varphi_d^*}$, $\frac{\partial \varphi_x^*}{\partial \varphi_d^*}$ and $\frac{\partial \varphi_{xf}^*}{\partial \varphi_{df}^*}$ are all positive. Consequently, the right-hand side of (2.23) and (2.24) must also monotonically decrease from infinity to zero on $(0, \infty)$. The left-hand side of these two equations are constant. Consequently, (2.23) identifies a unique cutoff level φ_d^* in China and (2.24) determines the industry productivity cutoff φ_{df}^* in Foreign Country. Having determined these two cutoffs, all other productivity cutoffs φ_s^* , φ_x^* and φ_{xf}^* follows immediately from the relationship between the productivity cutoffs from (2.20) - (2.22). These unique

⁷This proof is from Melitz (2003).

productivity cutoffs, in turn, determine the average productivity levels according to formulas (2.11) - (2.13). The *ex ante* successful entry in both countries, domestic and regular export probabilities are also fixed.

Aggregate revenue is exogenously determined and must equal the labor supply multiply wage, $R_i = w_i L$ in both countries. The price index P_c (2.25) has two components: the prices of a variety with weighted average productivity in China and Foreign Country, $p_c^d(\tilde{\varphi}_c^d)$ and $p_f^x(\tilde{\varphi}_f^x)$; the mass of foreign firms that export to China $M_f^x = p_f^x M_f$, and the mass of Chinese regular firms, M_c^d . The prices $p_c^d(\tilde{\varphi}_c^d)$ and $p_f^x(\tilde{\varphi}_f^x)$ depend solely on weighted average productivities in each market, $\tilde{\varphi}_c^d$ and $\tilde{\varphi}_f^x$, which in turn depend solely by two productivity cutoffs, φ_d^* and φ_{xf}^* , that were determined in (2.12) and (2.17). The probability of foreign firms export to China, $p_f^x = [1 - G(\varphi_{xf}^*)]/[1 - G(\varphi_{df}^*)]$, also follows from the two productivity cutoffs, φ_{df}^* and φ_{xf}^* . Similarly, the price index P_f (2.26) in Foreign Country consists of three terms: the prices of a variety with weighted average productivity from foreign producers $p_f^d(\tilde{\varphi}_f^d)$, Chinese processing exporters $p_c^s(\tilde{\varphi}_c^s)$ and regular ones $p_c^x(\tilde{\varphi}_c^x)$; the mass of foreign firms M_f , the mass of Chinese processing exporters M_c^s and regular exporters M_c^x . The prices $p_f^d(\tilde{\varphi}_f^d)$, $p_c^s(\tilde{\varphi}_c^s)$ and $p_c^x(\tilde{\varphi}_c^x)$ are solely rely on three productivity cutoffs, φ_{df}^* , φ_s^* and φ_x^* that were determined above. The probability of being Chinese processing exporters, $p_c^s = [G(\varphi_d^*) - G(\varphi_s^*)]/[1 - G(\varphi_s^*)]$, and the probability of regular export from China to Foreign Country $p_c^x = [1 - G(\varphi_x^*)]/[1 - G(\varphi_d^*)]$, also follows from the productivity cutoffs, φ_s^* , φ_d^* and φ_x^* . Finally, the mass of firms in both regions equals the ratio of aggregate revenue to average revenue, as shown in (2.27) and (2.28). Aggregate revenue was solved above, while average revenue depends solely on the already-determined productive cutoffs. This completes the characterization of the equilibrium.

Welfare

Welfare in Chinese market can also be written as a function of the cutoff productivity of φ_d^* :

$$\mathbb{W}_c = \frac{w_c}{R_c} = \rho \left(\frac{L}{\sigma w_c (f + f_d)} \right)^{\frac{1}{\sigma-1}} \varphi_d^*. \quad (2.37)$$

Similarly, welfare per worker in Foreign country is determined by the domestic zero cutoff profit condition:

$$\mathbb{W}_f = \frac{w_f}{R_f} = \rho \left(\frac{L}{\sigma w_f (f + f_d)} \right)^{\frac{1}{\sigma-1}} \varphi_{df}^*. \quad (2.38)$$

Since $\varphi_{df}^* > \varphi_d^*$, welfare in foreign country must be higher than in China: $\mathbb{W}_f > \mathbb{W}_c$.

2.6.3 The Impact of Trade Liberalization

These comparative statics are all derived from the equilibrium condition for the cutoff levels from (2.23) and (2.24); and the implicit definition of φ_x^* and φ_s^* as a function of φ_d^* from (2.17) and (2.20) in China; φ_{xf}^* as a function of φ_{df}^* from (2.21) in Foreign Country.

Decrease in Fixed Export Trade Costs

Changes in the cutoff levels:

Differentiating f_x with respect to $\varphi_x^* = \tau\varphi_d^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_x^*}{\partial f_x} = \frac{1}{\sigma-1}\frac{\varphi_x^*}{f_x} + \frac{\varphi_x^*}{\varphi_d^*}\frac{\partial\varphi_d^*}{\partial f_x}$.

Differentiating f_x with respect to $\varphi_s^* = \tau\varphi_d^*\left(\frac{f}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_s^*}{\partial f_x} = \frac{\varphi_s^*}{\varphi_d^*}\frac{\partial\varphi_d^*}{\partial f_x}$.

Differentiating f_x with respect to $\varphi_{xf}^* = \tau\varphi_{df}^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_{xf}^*}{\partial f_x} = \frac{1}{\sigma-1}\frac{\varphi_{xf}^*}{f_x} + \frac{\varphi_{xf}^*}{\varphi_{df}^*}\frac{\partial\varphi_{df}^*}{\partial f_x}$.

Differentiating free entry conditions of (2.23) and (2.24) in both countries with respect to f_x , we obtain

$$\begin{aligned} fJ'(\varphi_s^*)\frac{\partial\varphi_s^*}{\partial f_x} + (f+f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial f_x} + J(\varphi_x^*) + f_xJ'(\varphi_x^*)\frac{\partial\varphi_x^*}{\partial f_x} &= 0 \\ (f+f_d)J'(\varphi_{df}^*)\frac{\partial\varphi_{df}^*}{\partial f_x} + J(\varphi_{xf}^*)f_xJ'(\varphi_{xf}^*)\frac{\partial\varphi_{xf}^*}{\partial f_x} &= 0 \end{aligned}$$

Combining the above conditions yields:

$$\begin{aligned} \frac{\partial\varphi_d^*}{\partial f_x} &= \frac{1 - G(\varphi_x^*)}{fJ'(\varphi_s^*)\frac{\varphi_s^*}{\varphi_d^*} + (f+f_d)J'(\varphi_d^*) + f_xJ'(\varphi_x^*)\frac{\varphi_x^*}{\varphi_d^*}} < 0, \\ \frac{\partial\varphi_{df}^*}{\partial f_x} &= \frac{1 - G(\varphi_{xf}^*)}{(f+f_d)J'(\varphi_{df}^*) + f_xJ'(\varphi_{xf}^*)\frac{\varphi_{xf}^*}{\varphi_{df}^*}} < 0, \end{aligned}$$

since $J'(\varphi) < 0 \forall \varphi$, and

$$\begin{aligned} \frac{\partial\varphi_x^*}{\partial f_x} &= -\frac{1}{f_xJ'(\varphi_x^*)} \left[(f+f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial f_x} + fJ'(\varphi_s^*)\frac{\varphi_s^*}{\varphi_x^*}\frac{\partial\varphi_d^*}{\partial f_x} + J(\varphi_x^*) \right] > 0, \\ \frac{\partial\varphi_s^*}{\partial f_x} &= \frac{\varphi_s^*}{\varphi_d^*}\frac{\partial\varphi_d^*}{\partial f_x} < 0, \\ \frac{\partial\varphi_{xf}^*}{\partial f_x} &= -\frac{1}{f_{xf}J'(\varphi_{xf}^*)} \left[J(\varphi_{xf}^*) + (f+f_d)J'(\varphi_{df}^*)\frac{\partial\varphi_{df}^*}{\partial f_x} \right] > 0. \end{aligned}$$

Welfare: Recall from (2.37) and (2.38) that welfare must therefore rise with the decrease in f_x since all of these changes induce an increase in the domestic cutoff productivity levels φ_d^* and φ_{df}^* .

The decrease in fixed export cost f_x induces an increase in the cutoff productivity level of processing exporters. Recall that $r_c^s(\varphi) = (\varphi/\varphi_s^*)^{\sigma-1}\sigma w_c f$ ($\forall \varphi_s^* \leq \varphi < \varphi_d^*$).

$r_c^s(\varphi)$ therefore decreases with falling export barriers since this change induces an increase in the cutoff productivity level. Thus $r_c^{s'}(\varphi) < r_c^s(\varphi)$ whenever $f_x' < f_x$ since $\varphi_s^{*'} > \varphi_s^*$. In other words, the decline in export market access costs drives the least efficient processing exporters out of the market, and reduces revenue and profits of all existing processing exporters.

A decrease in f_x induces an increase in the domestic cutoff levels in both countries. Take China as an example, recall that $r_c^d(\varphi) = (\varphi/\varphi_d^{*\sigma-1})\sigma w_c(f + f_d) \forall \varphi \geq \varphi_d^*$. Thus, $r_c^{d'}(\varphi) < r_c^d(\varphi)$, $\forall \varphi \geq \varphi_d^{*'} since $\varphi_d^{*'} > \varphi_d^*$. All existing domestic producers in the new equilibrium with f_x' fixed export cost lose a fraction of revenue from the domestic market. In particular, regular producers in China with productivity levels between φ_d^* and $\varphi_d^{*'}$ switch to pursue processing trade, while the foreign firms with productivity $\varphi \in [\varphi_{df}^*, \varphi_{df}^{*'}]$ exit.$

For firms that already exported ($\varphi \geq \varphi_x^*$) prior to the change in f_x , the direction of change in combined domestic and export sales $r_c^d(\varphi) + r_c^x(\varphi) = (1 + \tau^{1-\sigma})r_c^d(\varphi)$ decreases in the same proportion as its domestic sales when f_x decreases since $1 + \tau^{\sigma-1}$ remains constant.

Trade liberalization in f_x reduces the regular export cutoffs in both regions, and hence generates a new category of firms with intermediate productivity levels ($\varphi_x^{*'} \leq \varphi < \varphi_x^*$) that enters the export market as a consequence of the decrease in f_x . The new export sales generate an increase in revenue for all these firms since $r_c^d(\varphi) < r_c^c(\varphi) + r_c^x(\varphi) = (1 + \tau^{\sigma-1})r_c^d(\varphi)$.

Decrease in Variable Trade Costs

Changes in the cutoff levels:

Differentiating τ with respect to $\varphi_x^* = \tau\varphi_d^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_x^*}{\partial\tau} = \frac{\varphi_x^*}{\tau} + \frac{\varphi_x^*}{\varphi_d^*} \frac{\partial\varphi_d^*}{\partial\tau}$.

Differentiating τ with respect to $\varphi_s^* = \tau\varphi_d^*\left(\frac{f}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_s^*}{\partial\tau} = \frac{\varphi_s^*}{\tau} + \frac{\varphi_s^*}{\varphi_d^*} \frac{\partial\varphi_d^*}{\partial\tau}$.

Differentiating τ with respect to $\varphi_{xf}^* = \tau\varphi_{df}^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_{xf}^*}{\partial\tau} = \frac{\varphi_{xf}^*}{\tau} + \frac{\varphi_{xf}^*}{\varphi_{df}^*} \frac{\partial\varphi_{df}^*}{\partial\tau}$.

Differentiating (2.23) and (2.24) in both countries with respect to τ yields:

$$\begin{aligned} fJ'(\varphi_s^*)\frac{\partial\varphi_s^*}{\partial\tau} + (f + f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial\tau} + f_xJ'(\varphi_x^*)\frac{\partial\varphi_x^*}{\partial\tau} &= 0 \\ (f + f_d)J'(\varphi_{df}^*)\frac{\partial\varphi_{df}^*}{\partial\tau} + f_xJ'(\varphi_{xf}^*)\frac{\partial\varphi_{xf}^*}{\partial\tau} &= 0 \end{aligned}$$

Combining the above conditions together yields:

$$\frac{\partial\varphi_d^*}{\partial\tau} = -\frac{\varphi_d^*}{\tau} \frac{fJ'(\varphi_s^*)\varphi_s^* + f_xJ'(\varphi_x^*)\varphi_x^*}{fJ'(\varphi_s^*)\varphi_s^* + (f + f_d)J'(\varphi_d^*)\varphi_d^* + f_xJ'(\varphi_x^*)\varphi_x^*} < 0, \quad (2.39)$$

$$\frac{\partial\varphi_{df}^*}{\partial\tau} = -\frac{\varphi_{df}^*}{\tau} \frac{f_xJ'(\varphi_{xf}^*)\varphi_{xf}^*}{(f + f_d)J'(\varphi_{df}^*)\varphi_{df}^* + f_xJ'(\varphi_{xf}^*)\varphi_{xf}^*} < 0, \quad (2.40)$$

since $J'(\varphi) < 0 \forall \varphi$, and

$$\begin{aligned}\frac{\partial \varphi_s^*}{\partial \tau} &= -\frac{(f + f_d)J'(\varphi_d^*)}{fJ'(\varphi_s^*) + f_x J'(\varphi_x^*) \frac{\varphi_x^*}{\varphi_s^*}} \frac{\partial \varphi_d^*}{\partial \tau} > 0, \\ \frac{\partial \varphi_x^*}{\partial \tau} &= -\frac{(f + f_d)J'(\varphi_d^*)}{fJ'(\varphi_s^*) \frac{\varphi_s^*}{\varphi_x^*} + f_x J'(\varphi_x^*)} \frac{\partial \varphi_d^*}{\partial \tau} > 0, \\ \frac{\partial \varphi_{xf}^*}{\partial \tau} &= -\frac{(f + f_d)J'(\varphi_{df}^*)}{f_x J(\varphi_{xf}^*)} \frac{\partial \varphi_{df}^*}{\partial \tau} > 0.\end{aligned}$$

Welfare: Recall from (2.37) and (2.38) that welfare must therefore rise with decrease in τ since all of these changes induce an increase in the cutoff productivity levels φ_d^* and φ_{df}^* .

As stated previously, we have $r_c^s(\varphi) = (\varphi/\varphi_s^*)^{\sigma-1} \sigma w_c f$ ($\forall \varphi_s^* \leq \varphi < \varphi_d^*$). $r_c^s(\varphi)$ therefore increases with decreases in τ since this change induces a decrease in the cutoff productivity of processing exporters ($\varphi_s^* \downarrow$). Thus $r_c^{s'}(\varphi) > r_c^s(\varphi) \forall \varphi_s^* \leq \varphi < \varphi_d^*$ whenever $\tau' < \tau$ (since $\varphi_s^{*'} < \varphi_s^*$).

With respect to Chinese domestic producers, recall that $r_c^d(\varphi) = (\varphi/\varphi_d^*)^{\sigma-1} \sigma w_c (f + f_d)$ ($\forall \varphi \geq \varphi_d^*$). A decrease in τ induce an increase in the domestic cutoff productivity level ($\varphi_d^* \uparrow$) and $r_c^d(\varphi)$ therefore decreases. Foreign Country also behaves the similar pattern that freer trade improves the industry productivity threshold and reduces the revenue and profits of all existing domestic firms. However, in contrast to Foreign Country, a set of Chinese firms with productivity $\varphi \in [\varphi_d^*, \varphi_d^{*'}]$ which would have otherwise been forced to exit switching to processing trade in face of decreasing τ .

Take China as an example, the direction of the change in combined domestic and export sales of Chinese regular exporters, $r_c^d(\varphi) + r_c^x(\varphi) = (1 + \tau^{1-\sigma})r_c^d(\varphi)$ ⁸, will depend on the direction of the change in $(1 + \tau^{1-\sigma})/(\varphi_d^*)^{\sigma-1}$. It is now shown that these combined sales increase when τ decreases as $(1 + \tau^{1-\sigma})/(\varphi_d^*)^{\sigma-1}$ then increases:

$$\begin{aligned}-\frac{\partial \varphi_d^*}{\partial \tau} \frac{\tau}{\varphi_d^*} &= \left[1 + \frac{(f + f_d)J'(\varphi_d^*)\varphi_d^*}{fJ'(\varphi_s^*)\varphi_s^* + f_x J'(\varphi_x^*)\varphi_x^*} \right]^{-1} \\ &= \left[1 + \tau^{\sigma-1} \frac{\int_{\varphi_d^*}^{\infty} x^{\sigma-1} g(x) dx}{\underbrace{\int_{\varphi_s^*}^{\varphi_d^*} x^{\sigma-1} g(x) dx + \int_{\varphi_x^*}^{\infty} x^{\sigma-1} g(x) dx}_{=0, \text{ since } \varphi_d^* \notin [\varphi_s^*, \varphi_d^*]}} \right]^{-1} \\ &= \left[1 + \tau^{\sigma-1} \frac{\int_{\varphi_d^*}^{\infty} x^{\sigma-1} g(x) dx}{\int_{\varphi_x^*}^{\infty} x^{\sigma-1} g(x) dx} \right]^{-1}\end{aligned}$$

⁸Recall that $r_c^x(\varphi) = \tau^{1-\sigma} r_c^d(\varphi)$, $\forall \varphi \geq \varphi_d^*$

$$< \left[1 + \tau^{\sigma-1} \right]$$

since $\int_{\varphi_d^*}^{\infty} x^{\sigma-1} g(x) dx / \int_{\varphi_x^*}^{\infty} x^{\sigma-1} g(x) dx > 1$ as $\varphi_d^* < \varphi_x^*$. Hence,

$$\begin{aligned} \frac{\partial \left[\frac{1+\tau^{1-\sigma}}{(\varphi_d^*)^{\sigma-1}} \right]}{\partial \tau} &= \frac{1+\tau^{1-\sigma}}{(\varphi_d^*)^{\sigma-1} \tau} \left[\frac{(1-\sigma)\tau^{1-\sigma}}{1+\tau^{1-\sigma}} - (\sigma-1) \frac{\partial \varphi_d^*}{\partial \tau} \frac{\tau}{\varphi_d^*} \right] \\ &= \frac{1+\tau^{1-\sigma}}{(\varphi_d^*)^{\sigma-1} \tau} (\sigma-1) \left[- \frac{\partial \varphi_d^*}{\partial \tau} \frac{\tau}{\varphi_d^*} - \left(1 + \tau^{\sigma-1} \right)^{-1} \right] \\ &< 0. \end{aligned}$$

That is, the combined sales of regular exporters rise when τ decrease.

The profit change of a processing exporter ($\varphi_s^* \leq \varphi < \varphi_d^*$) that is already in processing trade prior to falling τ can be written as:

$$\begin{aligned} \Delta \pi_c^s(\varphi) &= \pi_c^{s'}(\varphi) - \pi_c^s(\varphi) \\ &= \frac{1}{\sigma} [r_c^{s'}(\varphi) - r_c^s(\varphi)] \\ &= \varphi^{\sigma-1} f w_c \left[\frac{1}{(\varphi_s^{*'})^{\sigma-1}} - \frac{1}{(\varphi_s^*)^{\sigma-1}} \right], \end{aligned}$$

the term in the bracket is positive since $\varphi_s^{*'} < \varphi_s^*$. The processing exporter that export both before and after the change in τ enjoy a profit increases.

The drop in τ forces previous less efficient domestic producers with productivity level ($\varphi_d^* \leq \varphi < \varphi_d^{*'}\prime$) in China pursuing processing trade, the profit change of this type of firms can be written as:

$$\begin{aligned} \Delta \pi(\varphi) &= \pi_c^s(\varphi) - \pi_c^d(\varphi) \\ &= \frac{1}{\sigma} [r_c^s(\varphi) - r_c^d(\varphi)] - f_d w_c \\ &= w_c \varphi^{\sigma-1} \left(\frac{f}{\varphi_s^{*\sigma-1}} - \frac{f+f_d}{\varphi_d^{*\sigma-1}} \right) - f_d w_c, \end{aligned}$$

substituting (2.7) and (2.8) into the above equation reveals the term in the bracket must be negative. The switching from regular production mode to processing trade incurs both revenue and profit loss.

As was the case with the decrease in f_x , falling variable trade costs τ shift down the export productivity level from φ_x^* to $\varphi_x^{*'}\prime$. This generates the entry of new firms into the export market. All the new regular exporters enjoy a revenue gain, but only a portion of these firms also increase their profits. Specifically, this profit change is negative for the new exporting firms with the cutoff productivity level $\varphi_x^{*'}\prime$

$$\Delta \pi(\varphi_x^{*'}) = \frac{r_c^{d'}(\varphi_x^{*'})}{\sigma} + \frac{r_c^x(\varphi_x^{*'})}{\sigma} - (f+f_d+f_x)w_c - \left[\frac{r_c^d(\varphi_x^{*'})}{\sigma} - (f+f_d)w_c \right]$$

$$\begin{aligned}
&= \frac{r_c^{d'}(\varphi_x^*)}{\sigma} + \underbrace{\frac{r_c^{x'}(\varphi_x^*)}{\sigma} - f_x w_c}_{=\pi_x^c(\varphi_x^*)=0} - \frac{r_c^d(\varphi_x^*)}{\sigma} \\
&= \frac{1}{\sigma}(r_c^{d'}(\varphi_x^*) - r_c^d(\varphi_x^*)) < 0.
\end{aligned}$$

Therefore, the firms with productivity $\varphi > \varphi^\dagger$ where $\varphi_x^* < \varphi^\dagger < \varphi^*$ increase their profits. Firms with productivity level $\varphi > \varphi^*$ that export both before and after the change in τ enjoy a profit increase that is proportional to their combined revenue increase (their fixed costs do not change) and is increasing in their productivity φ :

$$\begin{aligned}
\Delta\pi(\varphi) &= \frac{1}{\sigma}[r'(\varphi) - r(\varphi)] \\
&= \varphi^{\sigma-1} f w_c \left[\frac{1 + (\tau')^{\sigma-1}}{(\varphi_d^*)^{\sigma-1}} - \frac{1 + \tau^{\sigma-1}}{(\varphi_d^*)^{\sigma-1}} \right],
\end{aligned}$$

where the term in the bracket must be positive.

Decrease in Domestic Trade Costs

Changes in the cutoff levels:

Differentiating f_d with respect to $\varphi_x^* = \tau\varphi_d^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_x^*}{\partial f_d} = \frac{1}{1-\sigma}\frac{\varphi_x^*}{f+f_d} + \frac{\varphi_x^*}{\varphi_d^*}\frac{\partial\varphi_d^*}{\partial f_d}$.

Differentiating f_d with respect to $\varphi_s^* = \tau\varphi_d^*\left(\frac{f}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_s^*}{\partial f_d} = \frac{1}{1-\sigma}\frac{\varphi_s^*}{f+f_d} + \frac{\varphi_s^*}{\varphi_d^*}\frac{\partial\varphi_d^*}{\partial f_d}$.

Differentiating f_d with respect to $\varphi_{xf}^* = \tau\varphi_{df}^*\left(\frac{f_x}{f+f_d}\right)^{\frac{1}{\sigma-1}}$ yields $\frac{\partial\varphi_{xf}^*}{\partial f_d} = \frac{1}{1-\sigma}\frac{\varphi_{xf}^*}{f+f_d} + \frac{\varphi_{xf}^*}{\varphi_{df}^*}\frac{\partial\varphi_{df}^*}{\partial f_d}$.

Differentiating (2.23) and (2.24) in both countries with respect to f_d and using the above three conditions

$$\frac{\partial\varphi_d^*}{\partial f_d} = \frac{\frac{1}{\sigma-1}\frac{f}{f+f_d}J'(\varphi_s^*)\varphi_s^* + \frac{1}{\sigma-1}\frac{f_x}{f+f_d}J'(\varphi_x^*)\varphi_x^* - J(\varphi_d^*)}{fJ'(\varphi_s^*)\frac{\varphi_s^*}{\varphi_d^*} + (f+f_d)J'(\varphi_d^*) + f_xJ'(\varphi_x^*)\frac{\varphi_x^*}{\varphi_d^*}} > 0, \quad (2.41)$$

$$\frac{\partial\varphi_{df}^*}{\partial f_d} = \frac{\frac{1}{\sigma-1}\frac{f_x}{f+f_d}J'(\varphi_{xf}^*)\varphi_{xf}^* - J(\varphi_{df}^*)}{(f+f_d)J'(\varphi_{df}^*) + f_xJ'(\varphi_{xf}^*)\frac{\varphi_{xf}^*}{\varphi_{df}^*}} > 0. \quad (2.42)$$

Since in China $J'(\varphi_d^*) < 0 \forall \varphi$, and $(f+f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial f_d} + J(\varphi_d^*) < 0$

$$\frac{\partial\varphi_x^*}{\partial f_d} = -\frac{(f+f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial f_d} + J(\varphi_d^*)}{fJ'(\varphi_s^*)\frac{\varphi_s^*}{\varphi_x^*} + f_xJ'(\varphi_x^*)} < 0,$$

$$\frac{\partial\varphi_s^*}{\partial f_d} = -\frac{(f+f_d)J'(\varphi_d^*)\frac{\partial\varphi_d^*}{\partial f_d} + J(\varphi_d^*)}{fJ'(\varphi_s^*) + f_xJ'(\varphi_x^*)\frac{\varphi_x^*}{\varphi_s^*}} < 0.$$

And in Foreign Country $J'(\varphi_{df}^*) < 0 \forall \varphi$, and $(f+f_d)J'(\varphi_{df}^*)\frac{\partial\varphi_{df}^*}{\partial f_d} + J(\varphi_{df}^*) < 0$

$$\frac{\partial\varphi_{xf}^*}{\partial f_d} = -\frac{J(\varphi_{df}^*) + (f+f_d)J'(\varphi_{df}^*)\frac{\partial\varphi_{df}^*}{\partial f_d}}{f_xJ'(\varphi_{xf}^*)} < 0.$$

Welfare

Recall the welfare per worker in China is $\mathbb{W}_c = \frac{w_c}{R_c} = \rho \left(\frac{L}{\sigma w_c (f + f_d)} \right)^{\frac{1}{\sigma-1}} \varphi_d^*$. The direction of the welfare change induced by a drop in the domestic trade costs is not immediately obvious as f_d enters into the welfare equation. (Recall that a decrease in f_d induces a decline in φ_d^* as $\frac{\partial \varphi_d^*}{\partial f_d} > 0$). The direction of the welfare change therefore depends on the direction of the change in $\frac{(\varphi_d^*)^{\sigma-1}}{f + f_d}$.

Proof that $\frac{(\varphi_d^*)^{\sigma-1}}{f + f_d}$ Increases when f_d decreases

The differential change in $\frac{(\varphi_d^*)^{\sigma-1}}{f + f_d}$ is given by:

$$\frac{\partial \left(\frac{\varphi_d^{*\sigma-1}}{f + f_d} \right)}{\partial f_d} = \frac{\varphi_d^{*\sigma-1}}{(f + f_d)^2} \left[(\sigma - 1) \frac{\partial \varphi_d^*}{\partial f_d} \frac{f + f_d}{\varphi_d^*} - 1 \right] < 0. \quad (2.43)$$

Hence, a decrease in f_d generates a welfare gain.

Recall that the aggregate revenue of domestic firms is exogenously given by $R_c = w_c L$ and $R_f = w_f L$. Hence, $r_c^s(\varphi)/R_f$ represents a Chinese processing exporter's market share in Foreign Country. In addition, we have $r_c^s(\varphi) = (\varphi/\varphi_s^*)^{\sigma-1} \sigma w_c f$ ($\forall \varphi_s^* \leq \varphi < \varphi_d^*$). $r_c^s(\varphi)$ therefore decreases with falling domestic trade barriers f_d since this change induces a rise in the cutoff productivity level of processing exporters ($\varphi_s^* \uparrow$). Thus $r_c^{s'}(\varphi) < r_c^s(\varphi) \forall \varphi_s^* \leq \varphi < \varphi_d^*$ whenever $f_d' < f_d$ (since $\varphi_s^{*'} > \varphi_s^*$).

Falling f_d creates the entry of new regular producers in both countries. Take China as an example, a decline in f_d leads to efficient processing exporters switching from processing trade to regular production and starting to serve the domestic market. For a new domestic firm ($\varphi_d^{*'} < \varphi \leq \varphi_d^*$), the profit change can be written:

$$\begin{aligned} \Delta \pi(\varphi) &= \pi_c^d(\varphi) - \pi_c^s(\varphi) \\ &= \frac{1}{\sigma} [r_c^d(\varphi) - r_c^s(\varphi)] - f_d w_c \\ &= w_c \varphi^{\sigma-1} \left(\frac{f + f_d}{\varphi_d^{*\sigma-1}} - \frac{f}{\varphi_s^{*\sigma-1}} \right) - f_d w_c, \end{aligned} \quad (2.44)$$

substituting (2.7) and (2.8) into the above equation reveals the term in the bracket must be positive. The profit change $\Delta \pi(\varphi)$ is thus an increasing function of firm's productivity φ . Therefore, the new domestic firms increase their revenue and profits. The impact of changing production mode is similar to Melitz (2003) of moving from autarky to trade.

For Chinese firms ($\varphi_d^* \leq \varphi < \varphi_x^*$) that already in domestic market prior to the change in f_d , the impact of falling f_d on the profit is

$$\Delta \pi(\varphi) = \pi_c^{d'}(\varphi) - \pi_c^d(\varphi)$$

$$\begin{aligned}
&= \frac{1}{\sigma} [r_c^{d'}(\varphi) - r_c^d(\varphi)] - (f + f_d')w_c - (f + f_d)w_c \\
&= w_c \varphi^{\sigma-1} \left[\frac{f + f_d'}{(\varphi_d^*)^{\sigma-1}} - \frac{f + f_d}{\varphi_d^{*\sigma-1}} \right] - (f_d' - f_d)w_c
\end{aligned} \tag{2.45}$$

(2.43) reveals $\frac{\partial(\frac{f+f_d}{\varphi_d^{*\sigma-1}})}{\partial f_d} > 0$. This implies that $\frac{f+f_d}{\varphi_d^{*\sigma-1}}$ decreases when f_d falling down and hence that $\frac{f+f_d'}{(\varphi_d^*)^{\sigma-1}} < \frac{f+f_d}{\varphi_d^{*\sigma-1}}$. This inequality implies that the $\Delta\pi(\varphi)$ is a decreasing function of φ since the bracket in (2.45) is negative. Therefore, an existing domestic producer experiences both revenue and profits loss in the new equilibrium.

The change in profits earned by a firm that export in the new equilibrium ($\varphi \geq \varphi_x^*$) can be written:

$$\Delta\pi(\varphi) = (1 + \tau^{1-\sigma})\varphi^{\sigma-1}w_c \left[\frac{f + f_d'}{(\varphi_d^*)^{\sigma-1}} - \frac{f + f_d}{\varphi_d^{*\sigma-1}} \right] - (f_d' - f_d)w_c.$$

The direction of the change in combined domestic and export sales also depends on $\frac{f+f_d}{\varphi_d^{*\sigma-1}}$. It showed above that these combined profit will decrease when f_d decreases.

Chapter 3

Multi-product Exporters and Antidumping: Evidence from China

Abstract

I investigate how Chinese exporters respond to tariff shocks that arise from US antidumping measures. Using Chinese customs data between 2000 and 2006, I provide strong evidence that antidumping measures severely distort bilateral trade between China and the US. I do not find any evidence that the US import restrictions resulted in any changes of Chinese exports to alternative markets. I then explore the adjustments at the firm level. I document that Chinese firms that were hit with antidumping measures reduce their exports of the targeted products not only to the US but also to alternative markets, suggesting negative spillover effects. More importantly, antidumping measures are associated with deterrent effects on other products and markets within firms. That is, multi-product firms reduce their exports of other unaffected products to alternative markets.

3.1 Introduction

Despite the growing trend of trade liberalization, the use of temporary trade barriers, such as antidumping and countervailing duties, and safeguards, is on the rise (see Blonigen and Prusa, 2016). Antidumping measures are particularly important as they are among the most intensively used forms of trade restrictions.¹ An importing country can levy duties on a trade partner if imported products are *dumped and causing injury to domestic import-competing industries* (WTO Antidumping Agreement, Article 3). Specifically, dumping refers to the practice of exporting a product at a price that is lower than the price usually charged in the home market or lower than its production

¹For example, according to WTO notifications, between 1995 and 2010 a total of 2503 antidumping measures were imposed worldwide, while in the same period safeguards and countervailing duties accounted for only 101 and 158 measures, respectively.

cost. The proliferation of antidumping measures has stimulated research to evaluate their effects on protected products, firms, and industries.

While the literature has generated significant insights on the effects of antidumping measures on the protected import-competing firms,² there is much scarcer analysis of the corresponding impact on affected foreign counterparts. How do antidumping measures halt trade flows? Do these import restrictions shift exports to alternative markets? How do the affected firms respond to these market-specific tariff shocks? Do they deflect the targeted products to third countries? Do these measures have spillover effects that go beyond the targeted products? Despite their importance for firm performance, the way these trade restrictions shape the export activities across products within firms remains poorly understood. In this paper, I attempt to fill these gaps by exploring the effects of US antidumping measures on the export behavior of Chinese firms. The analysis of how impacted firms respond to such trade restrictions could inform us of the true costs of antidumping measures on the exporting countries and present the story from a different angle.

China serves as a suitable country for this analysis for several reasons. First, it is one of the most targeted countries by antidumping investigations, and the US is the leading initiator. This is due to the fact that the US has an increasing trade deficit with China, and its loss of manufacturing employment (see Pierce and Schott, 2016; David et al., 2013). For example, China made up 20% of the US antidumping caseload between 2000 and 2006.³ Second, the US is a major trade partner with China, and it is one of the most important markets for Chinese exporters. For firms that have exported to the US from 2000 to 2006, 25% of their total export value was shipped to the US. This means that a substantial amount of trade could potentially be shifted to third markets upon the imposition of US trade restrictions. Third, there is a wealth of available data pertaining to Chinese firms covering a substantial period replete with antidumping practices, which makes China an exceptional case for identifying the impact of antidumping measures on firms.

The objective of this paper is to explore the patterns of export adjustments to antidumping shocks among firms. To do so, I employ a difference-in-differences (DID) approach. Specifically, my identification strategy is based on the comparison of outcome variables (e.g. participation, the number of exporters, export value, volume, and price) for firms exporting the targeted products, compared to firms that do not. That is, my treatment group consists of products that are under investigations and subject to antidumping duties (referred to *targeted* products). The control group includes all

²This includes Konings and Vandenbussche (2005, 2008, 2013); Pierce (2011).

³The US initiated a total of 247 antidumping investigations worldwide between 2000 and 2006, in which 48 caseloads were against China.

uninvestigated products within the 4-digit HS⁴ product category to which the affected products belong (referred to *closely-related* products).

I first examine the overall trade responses at the product level. Using detailed Chinese customs data between 2000 and 2006, I find strong evidence that US antidumping measures severely distort bilateral trade flows between these two countries. Specifically, antidumping-*targeted* products experience a drastic fall by somewhere between 50% and 85% in export flows. Additionally, there are significant adverse effects on the extensive margin. That is, antidumping measures decrease the probability of the *targeted* products to be exported and lead to a sharp decline in the number of exporters serving the US market. I then estimate the impact of US antidumping measures on Chinese exports to non-US markets. Surprisingly, I do not find evidence that the US import restrictions result in any changes of Chinese exports of the *targeted* products to alternative markets. That is, the changes in trade costs in one country do not affect the behavior of aggregate exports in another market, where the policy has not changed.

Nevertheless, the aggregate impact at the product level can hide large changes at the firm level. I therefore explore export adjustments within firms. Not much evidence exists concerning how exporting firms behave when faced with such export restrictions. The literature does not inform us whether the affected exporters stop shipping or reduce exports to the policy-imposing country. Also, it does not tell us whether exporting firms adjust their exports to other products and destinations.

To this end, I study how firms' specific patterns of trade are affected by this particular form of trade restriction. In particular, I look at changes in firms' behavior when confronted with regulatory barriers concerning participation in the export markets, values, quantities of exports, and pricing strategy. As antidumping measures in general take the form of ad-valorem tariffs, they can be thought of as export costs. Assuming the existence of a cost of entry in a certain market, recent trade models (e.g. Melitz, 2003) predict that only the most productive firms in the industry will continue to export after an increase in such costs. Therefore, the imposition of import restrictions could affect both the probability of entering a foreign market (extensive margin) and the associated export flows (intensive margin). Consistent with the literature, I find that Chinese firms that were subject to the US antidumping measures both reduce their probability of exporting the *targeted* products and restrict their existing trade flows to the US market.

I then turn to the question of whether the imposition of contingency tariffs on products, affect firms' exports to *other* markets as well. To answer this question, I compare the export patterns of the *punished* firms to the *unpunished* ones in alternative

⁴HS refers to the Harmonized System, which is an internationally standardized system of names and numbers to classify traded products.

markets. I find that Chinese firms that were exposed to the disruption of the US market decrease the probability of exporting the *targeted* products to alternative markets. They also reduce their export flows to third markets but charge higher prices. These findings suggest that antidumping measures may have a trade-reducing effect which spreads to other destinations within firms. Firms tend to curtail their export expansion in third markets by lowering volume and raising price to avoid further antidumping investigations.

A significant and novel contribution of this paper is that I study the extent to which a tariff shock from the US influences Chinese firms' export participation, value, volume, and prices for other untargeted products across markets. I first investigate whether firms reshuffle their exports to other products in the US market. I find that firms that have experienced the US trade shocks reduce their export of other uninvestigated products to the US. This finding suggests that antidumping creates unintended negative consequences that distort trade of the unaffected products within firms. I next discuss whether the US antidumping measures generate spillovers across products within firms to alternative markets. To this end, I assess how the relative changes in trade costs in one market impact firms' export decisions into *other* markets, where the policy has not changed. I find that firms that confronted antidumping measures in the US also reduced their trade in *other* markets. These observations imply that the imposition of antidumping duties by the US for one product, as an indicator of increased trade policy uncertainty, negatively spills over to other products and markets within firms.

Overall, my results show that the effects of antidumping measures on firms are complex. These measures do not only affect exports of the *targeted* products across destinations. More importantly, they generate a deterrent effect which chills trade in the other products of affected exporters. Hence, trade policy investigations aiming at specific products should not overlook their negative externalities beyond the *targeted* ones.

This paper advances the current literature in three ways. First, it builds on a small but growing literature documenting the effects of antidumping measures on firms from targeted countries. Lu et al. (2013) use monthly data on Chinese exports from 2000 to 2006 and find that there is a substantial negative effect of US antidumping protections on export volumes. Similarly, Chandra and Long (2013) document that the imposition of US antidumping duties decreases both Chinese firms' labor productivity and total factor productivity. My paper differs from prior studies in one key dimension in that I focus on within-firm adjustments. In light of the increasingly heavy use of antidumping measures, my estimates of these microeconomic effects are valuable additions to the current evaluation of such policies.

Secondly, my study sheds light on how trade policy uncertainty affects firms' export

decision (i.e., the extensive margin). My main result is that a tariff hike for one product in the US market is associated with a decline likelihood of that product being exported across markets from the same *punished* firm. Debaere and Mostashari (2010), for example, provide evidence that extensive margin responses to US tariff policy changes had an effect on overall US imports from that country. The negative effect that I observe is also in line with the finding presented in Crowley et al. (2018). They show that the use of antidumping measures in one market leads to a decline in entry both for the *targeted* and the *closely-related* products in that market.

Finally, my paper contributes to the literature that seeks to understand how changes in export costs have influenced within-firm adjustments across products and destinations. The relevance of this issue is highlighted in the work of Goldberg et al. (2010); Berthou and Fontagné (2013); Bernard et al. (2014), all of which show how a permanent reduction in trade costs affect the export margins of firms in relation to export decisions, the number of product exported, and the average sales per products. My paper complements their work by looking at how a temporary increase in trade barriers affects firms' export behavior.

The remainder of the paper is organized as follows. The next section provides a brief summary of an antidumping proceeding in the US. Section 3 defines the treatment and control groups, as well as a description of the estimation strategy. Section 4 describes the data used in the empirical analysis. Section 5 presents the empirical findings. Section 6 concludes.

3.2 The US Antidumping Procedures

In this section, I provide a brief overview of how an antidumping investigation in the US is carried out and describe the possible outcomes. A flow chart of the US antidumping proceedings is presented in Figure 3.7 in the Appendix.

To initiate an antidumping investigation, an interested party (e.g. domestic firms and/or labor unions) must file a petition and submit it to the relevant government agencies: the Department of Commerce (DoC) and the International Trade Commission (ITC). The petition contains two pieces of essential information for the analysis. First, it must specify the exact product that is alleged to have been dumped in the US. The product is defined at the US 8- or 10-digit HS level.⁵ Second, the petition has to indicate which country(-ies) is(are) allegedly dumping. Only the countries named in the petition are subject to the investigation.

⁵At the international level, the HS for classifying goods is a 6-digit code system. A code with a low number of digits defines broad categories of products; additional digits indicate sub-divisions into more detailed definitions. Countries can add more digits for their own coding to subdivide the definitions further according to their own needs.

Within 20 days, the DoC determines whether the petition is affirmative. If so, the investigation proceeds on a statutory timeline, with the DoC determining whether the product in question was sold at less than fair value (LTFV) and the ITC determining whether domestic firms suffered a material injury.

Within 45 days after the date of the filing of the petition, the ITC makes a preliminary determination on whether the domestic industry is suffering (or is threatened by) material injury. A negative preliminary decision would end the proceeding. With the affirmative preliminary ITC determination, the DoC makes a preliminary duty determination within the next 115 days, of whether the product named in the petition is sold at LTFV. If the DoC preliminary determination is affirmative, a preliminary duty is imposed from this time onwards. With a negative determination, the DoC nevertheless continues to conduct the investigation, although the preliminary duty is not imposed. The DoC makes a final determination of whether the subject imported merchandise is being sold or is likely to be sold at LTFV within 75 days of its preliminary decision.

If the DoC final determination is negative, the investigation is terminated. Otherwise, the ITC has 45 (or 75) days to conduct the final phase of investigation and make a determination. Once both the DoC and the ITC reach affirmative final determinations, the DoC issues an antidumping order to levy final antidumping duties within seven days. Once imposed, the antidumping duty can be in place for a maximum of five years, except if extended (always by sequences of a maximum of five years) through reviews because of evidence of continuing dumping and injury.

Antidumping measures usually take the form of an ad valorem duty, but could also be a specific duty, a price/quantity undertaking, or a combination of these. In either case, the measures are not only country-industry-wide duty but also firm-specific. That is, relevant US administrative agencies often calculate separate duties for individual companies that are responsible for the largest share of the investigated product. The remaining firms exporting the *targeted* product are subject to an industry-wide antidumping duty. As the US classifies China as a nonmarket economy (NME), Chinese domestic prices are considered unreliable, so a surrogate country is used to calculate the antidumping duty. In practice, firm-specific duties are substantially lower than the industry-wide one (see Figure 3.8 in the Appendix).

The overall investigation process for antidumping cases can be divided into three stages: (1) the initiation phase, (2) the preliminary duty phase, and (3) the final duty phase. The initiation phase refers to the period from initiation until any preliminary duty is levied. The preliminary duty phase starts from when the US importers have to pay the preliminary antidumping duty until the end of the investigation. During this stage, the investigation can be withdrawn by the petitioner(s) or suspended if an agreement is reached between the affected foreign exporters and the DoC. The final duty

phase begins on the date that the final antidumping duty is imposed and continues until the date the antidumping order is revoked. Antidumping investigations are usually concluded within one year (except in special circumstances when the investigation may last up to 18 months).

3.3 The Empirical Framework

I proceed with the empirical analysis in two steps. First, I estimate the trade effects of US antidumping measures on Chinese exports at the aggregate product level. Secondly, I drill down to firms by examining the adjustment across products and markets to shed light on how these import restrictions shape firms' specific patterns of trade. To this end, I also aim to link the export responses observed at the product level to the micro-level adjustments.

Following Lu et al. (2013), I define the treatment group as the products that are under investigation and subject to antidumping duties (*targeted* products). Each product in the treatment group is assigned a date of treatment and an ad-valorem duty. The control group contains all uninvestigated products within the 4-digit HS product category to which the *targeted* products belong (*closely-related* products). This procedure, therefore, constructs a set of control products that are similar to the treated products.

3.3.1 Product-level Framework

To evaluate the effects of antidumping measures on Chinese products, I follow Autor (2003) and pursue a dynamic difference-in-differences (DID) approach. Formally, I estimate their causal impact by contrasting the export patterns of the *targeted* and the *closely-related* products using the following specification:

$$\begin{aligned}
y_{pt}^d = & \gamma_t^d + \delta_p^d + \beta_{-9} D_{p,t+\tau(\tau \leq -9)}^d + \sum_{\tau=-8, \tau \neq -1}^8 \beta_{\tau} D_{p,t+\tau}^d \\
& + \beta_9 D_{p,t+\tau(\tau \geq 9)}^d + \sum_{\tau=-9}^9 \alpha_{\tau} \mathbf{1}(L_{pt}^{d,all} = \tau) + \varepsilon_{pt}^d,
\end{aligned} \tag{3.3.1}$$

where subscripts p , d and t indicate the 6-digit HS product category, destination and quarter respectively. I assume that the destination markets consist of the United States (US) and the Rest of the World (RoW). My dependent variables are: (i) a dummy variable taking a value of 1 for a product p that has positive trade flows into a certain destination market in quarter t (0 otherwise),⁶ reflecting export participation; (ii) the

⁶If we observe positive trade flows of a product p into a certain destination in quarter t but no export thereafter, we keep the zero observations in quarter $t - 1$ and $t + 1$.

number of exporters in each product-quarter combination in the US and the RoW; These two variables estimate the effect on the extensive margin. (iii) the products' export values and quantities (in logs) to the US and the RoW, with the inclusion of both positive trade values and zero trade flows (in logs). Including observations of China's exit from specific markets allows me to capture the phenomenon that products may cease being exported to the US entirely;⁷ and (iv) the log of export prices, proxied by unit values (the ratio of export value to quantity).

The quarter dummies, γ_t^d , control for overall trends and aggregate shocks that may affect all products. The 6-digit HS product fixed effects, δ_p^d , capture the time-invariant product characteristics. The treatment variables $D_{p,t+\tau}^d$ take the value of 1 for the *punished* product p in quarter t if it is exactly τ periods relative to the start of antidumping investigation for this product. That is, instead of a single treatment effect, I have included 8 anticipatory effects ($\beta_{-9} \dots \beta_{-2}$) and 10 post-treatment effects ($\beta_0 \dots \beta_9$). Of these 18 indicator variables, the indicator variable $D_{p,t+\tau(\tau \leq -9)}^d$ is equal to one in each quarter, end with the 9th quarter before the investigation, while $D_{p,t+\tau(\tau \geq 9)}^d$ is equal to 1 in each quarter, starting with the 9th quarter after the investigation. The remaining indicator variables are equal to 1 only in the relevant quarter. The leads and lags give the causal effect on the outcomes of interest τ quarters from the measures. I cluster the standard errors at the 6-digit HS product level throughout, considering the possible within-product correlation over time.

Crucially, following Jaravel et al. (2018), I include a set of leads and lags around the investigation time that is common to both the *targeted* and the *closely-related* products ($L_{pt}^{d,all}$). That is, I use the quarter of the initiation of investigations for the *targeted* products to impute the counter-factual time of the investigations for the *closely-related* products. Based on this, I can define "leads" and "lags" of the investigations for both treated and control groups. The terms $L_{pt}^{d,all}$ (i.e., investigation time fixed effects) sweep out the differences of various investigation time. Intuitively, these leads and lags address the concern that product and quarter fixed effects may not fully account for product specific trends.⁸ Indeed, I find that the set of leads and lags $L_{pt}^{d,all}$ has substantial predictive power for phenomena like trade deflection.

For the antidumping measures examined in this paper, I identify the investigation

⁷Specifically, if there is no export reported of product p in the quarter t , I fill it with 0. I follow the usual practice of adding one unit to all export flows before taking logarithms.

⁸In the standard DID estimator, treatment occurs at only one point in time and the regression includes a *Treated* dummy and *Treated* \times *Post* dummy. The standard DID specification is

$$y_{pt} = \alpha Treated_p + \beta^{All} Post_t + \beta^{Real} (Treated \times Post)_{pt} + \varepsilon_{pt}$$

In my setting, where antidumping investigations are scattered over time, $L_{pt}^{d,all}$ plays a role analogous to the *Post* dummy and $D_{p,t\pm\tau}^d$ plays a role analogous to *Treated* \times *Post* dummy.

time t as the *initiation* time of the antidumping investigation, as opposed to the time the final measure was imposed. This is motivated by prior research which has shown that antidumping investigations, regardless of the final decision, can have significant effects on trade (Staiger et al., 1994). The reference period is one quarter before the investigation so that all other treatment effects are expressed relative to the omitted period. As illustrated in Section 2, an antidumping investigation usually takes 280-420 days. Therefore, $\tau = 0 - 3$ represents the antidumping investigation process, while $\tau = 4$ is when the final duty is possibly levied. On the one hand, the coefficients $\beta_{-9} \dots \beta_{-2}$ show whether the treatment and control groups have common trends before the antidumping measures. If so, these coefficients should be jointly insignificant. On the other hand, the coefficients $\beta_0 \dots \beta_9$ show whether the treatment effect fades out, stays constant, or even increases over time.

With this empirical specification at hand, I first assess the trade destruction effect caused by antidumping measures in the US market. That is, I estimate how these measures destroy the trade of the *targeted* products from China to the US. However, the export restrictions to the US can give rise to trade deflection, where a destruction effect at the product level could be offset by an increase in product-level export to other countries. Specifically, I investigate whether the US import constraints impose externalities on Chinese exports, which result in surging of the *targeted* products to alternative markets.

3.3.2 Firm-level Framework

The preceding subsection focuses on the effects of antidumping measures on aggregate trade. But an important and related question remains whether these trade restrictions alter individual firms' behavior. I therefore analyze how firms' export patterns (whether or not to export, and how much to export) and pricing strategy change when faced with antidumping duties. More importantly, I examine whether these trade shocks lead to the reallocation of activities across products and destinations within multi-product firms. To put it differently, I ask whether tightened trade policy against one product within a firm spills over to other products and markets. By focusing on the adjustments within firms, I aim to measure the myriad effects of antidumping duties on trade.

Figure 3.1 provides a graphical explanation of multi-product firms in my analysis. The *punished* firm is defined as an exporter of multiple 6-digit HS products both to the US and the RoW, where at least one of its products exporting to the US is subject to an antidumping duty in the US. In other words, every *punished* firm has direct experience of a tariff hike for a product in the US market. The *unpunished* firm refers to an exporter of a set of 6-digit products that do not face any antidumping duty

anywhere in the world. Products A and B are closely-related to each other, as they belong to the same 4-digit HS product category, but only product A is subject to an antidumping duty in the US.

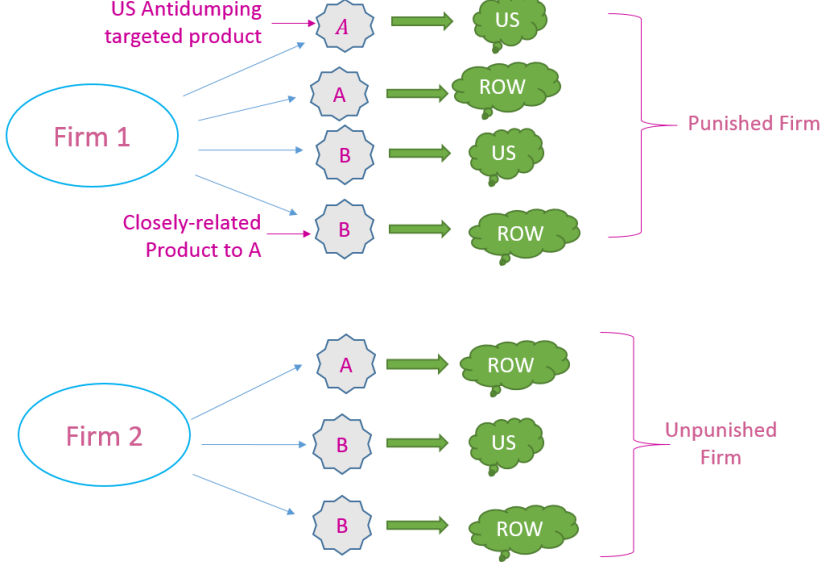


Figure 3.1: Product and market structure of multi-product firms

I again follow Autor (2003) and identify the dynamic effect of antidumping measures on firms using the following specification:

$$\begin{aligned}
 y_{fpt}^d = & \gamma_t^d + \delta_{fp}^d + \beta_{-4} D_{fp,t+\tau}^d (\tau \leq -4) + \sum_{\tau=-3, \tau \neq -1}^3 \beta_{\tau} D_{fp,t+\tau}^d \\
 & + \beta_4 D_{fp,t+\tau}^d (\tau \geq 4) + \sum_{\tau=-4}^4 \alpha_{\tau} \mathbf{1}(L_{fpt}^{d,all} = \tau) + \varepsilon_{fpt}^d,
 \end{aligned} \tag{3.3.2}$$

where the subscripts f , p , d and t denote firm, 6-digit HS product line, destination market and year, respectively. Notably, I aggregate the data at the annual level as most firms do not export a given product to a given market in every quarter.

My dependent variables are: (i) a dummy variable that equals 1 if a firm exports a 6-digit HS product to a market in year t (0 otherwise).⁹ This variable explores the extensive margin of trade, i.e., a firm's decision to participate in exporting to a certain market for a given product. The other dependent variables are: (ii) a firm's export values and quantities (in logs) in a market, where zero trade flows are retained from

⁹If we observe positive exports by a firm in year t but no export after that, we keep the zero observations in years $t-1$ and $t+1$.

the analysis; and (iii) the price of exported goods (in logs) in that market, proxied by unit values.

The explanatory variables are similar to equation (3.3.1). The coefficients of interest are β_τ , which measure the average difference between the control and treatment groups. The focal year t is the *initiation* year of the investigation, as opposed to the year that the final measure was actually imposed, though frequently they will be the same. Since a year dummy must be omitted, I follow the standard procedure of omitting the first year immediately preceding the investigation. In addition to year fixed effects, I include a set of firm-product fixed effects (λ_{fp}^d) to control for firm-product specific and time-invariant unobserved characteristics which might affect the trade performance of exporters. More importantly, I include a set of leads and lags around the investigation year that is common to both the *punished* and *unpunished* firms at the firm-product level ($L_{fpt}^{d,all}$).

Of particular note, both the extensive- and intensive margins effects are compounded by the entry and exit of exporters at the product level. That is, I have included exporters that exit the exporting markets for the pre-investigation period and the new entrants into exporting for the post-investigation period. Nevertheless, I concentrate on the surviving exporters and the exiters at the firm level.¹⁰ That is, I drop the firms that enter the exporting market after the policy change.

The data exhibit a substantial fraction of zeros at the firm-product-destination-year level, which represent over 50% of trade values and quantities. There may be two reasons for the zero trade flows: there truly is no bilateral trade, or bilateral trade values are not reported.¹¹ If I take the logarithm of the value or quantity of trade and use an OLS-based estimation methodology, all observations with zero trade flows would drop out of my estimation sample. This would likely create a bias in my estimated policy impact: if antidumping measures were prohibitive and caused Chinese exporters to completely stop exporting the product, then I would likely underestimate the true effect.

For this reason, I choose to include the zero observations by adding 1 to all export values and volumes before taking logs, so that the actual dependent variable is $\ln(1 + \text{EXP})$. This is a standard approach in the literature if one does not want to drop zero trade observations. As discussed in Head and Mayer (2014), there are some more sophisticated methods to deal with zeros, e.g. Poisson Pseudo ML estimation or Tobit regression, but these approaches come at the expense of losing the ability to introduce

¹⁰More precisely, surviving exporters are the firms that export at least once both before and after the policy shock. The exiters refer to firms that stop exporting completely after the policy shock.

¹¹Zero trade and missing trade values are typically not satisfactorily distinguishable in trade matrices.

controls. In my case, with the three sets of fixed effects, these methods are not possible without dropping the vast majority of controls.

Trade Destruction

Starting from equation 3.3.2, I first estimate the direct effect of how antidumping measures suppress trade on Chinese firms. Especially, the often very high tariff rates can imply substantial distortions, which lead to suboptimal use of scarce resources.

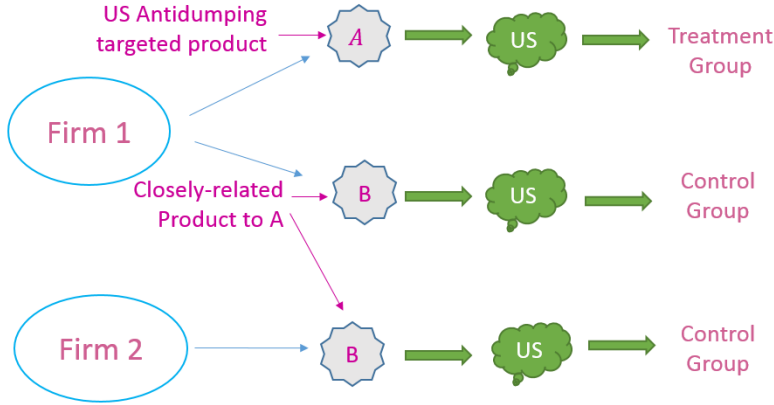


Figure 3.2: Trade destruction in the US at the firm-product level

Figure 3.2 provides a representation of the treatment and control groups for this analysis. The treatment group refers to firms exporting to the US a 6-digit HS product that is subject to an antidumping duty in the US. The control group consists of firm-product-destination triplets that do not face any antidumping duty anywhere in the world. The products in the control group include all the uninvestigated products within the 4-digit HS product category to which the *targeted* products belong. I do so to investigate the extent to which antidumping actions eliminate trade altogether both from the extensive and intensive margins.

Trade Deflection

As exporting to the US becomes tougher, firms may reallocate their exports to other existing markets or start a new trade relationship, or engage in both activities simultaneously to compensate their losses in the US market. Hence, I examine whether the US antidumping measures have caused Chinese firms to deflect trade, resulting in an increase in the exports of the *targeted* products to third (non-US) markets. Here, I compare the export performances in non-US markets of firms that have been directly exposed to the trade restrictions to that of non-exposed firms.

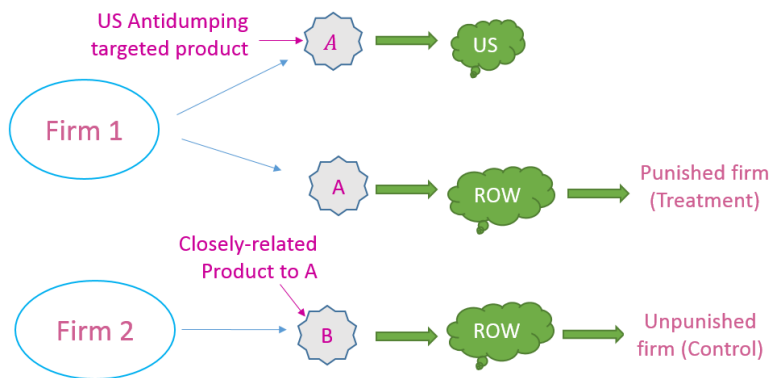


Figure 3.3: Trade deflection to the RoW at the firm-product level

Figure 3.3 outlines my comparison. Firm 1 the *punished* firm, which is hit with an antidumping duty as it exports the US antidumping *targeted* product *A* to the US. By contrast, Firm 2 is the *unpunished* firm, which is not hit with this tariff increase in the US because it exports product *B*, which is not subject to any antidumping duty anywhere in the world. I am interested in whether the restricted exporters increase their exports of the *targeted* products to other unrestricted third markets following the US export restrictions. The objective of this exercise is to investigate whether the use of antidumping measures has unintended consequences on trade that go beyond the affected partners.

Within-Firm Product Switching

To further enhance our understanding of antidumping measures, and in particular of how US antidumping measures against China spill over across products and markets within firms, I explore whether an antidumping action against one product influences firms' behavior (participation, value, volume shipped and price strategy) for other products both to the US and the RoW. Specifically, I consider that antidumping measures can have externalities that spread to other products within firms. Figure 3.4 illustrates this problem. Firm 1 is an antidumping-*punished* firm because it exports product *A* to the US, which is subject to an antidumping duty. I investigate the export pattern of Firm *A*'s *closely-related* product *B* both to the US and the RoW, to see whether a tariff hike for one product within a firm affects its export performance for other products.

In other words, I am concerned with the impact of the spread of antidumping measures on trade beyond the *targeted* products within firms. Previous research has largely neglected the externality effect that antidumping measures may have on other products than just the *targeted* ones. Therefore, testing for the presence of spillover

effects to other product categories allows me to quantify the true costs of antidumping measures on the restricted exporters.

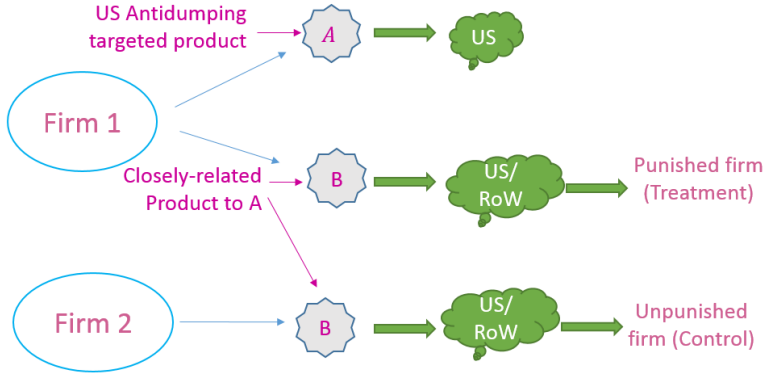


Figure 3.4: Within-firm product switching behavior to the US/RoW

3.4 Data

I employ data from the following sources: the Global Antidumping Database (Bown, 2015) and Chinese customs data between 2000 and 2006.¹²

The antidumping data come from the Global Antidumping Database (GAD) of the World Bank. They cover all antidumping cases by all user countries in the world, with each investigation mapped to the targeted HS codes from 1980 to 2014. For each antidumping case, the GAD includes detailed product information (classified at the 10-digit HS level), the initiation date, the preliminary and final determination dates and decisions, along with the final remedy. I focus on all the antidumping proceedings carried out by the US against China between 2000 and 2006. I aggregate these products from the 10-digit to the 6-digit HS level.

The Chinese firms' cross-border transaction-level data are obtained from China's General Administration of Customs. It records monthly import and export transactions of all Chinese firms with universal trading partners from 2000 to 2006. Each trade is recorded at the Chinese 8-digit HS level¹³ with a quantity, a value, and a unit value as the ratio of the shipment value to quantity. Quantity is measured by one of twelve different units of measurement (such as kilograms, square meters, *et cetera*). Values and unit values are in current US dollar.

¹²I thank Nankai University for providing the data.

¹³The number of distinct product codes in the Chinese 8-digit HS classification is comparable to that in the 10-digit HS trade data for the US (Manova and Yu, 2016).

At the product-level, I aggregate the monthly customs data to the quarterly level in order to avoid the noise that characterizes monthly data, and hence to have more precise estimates. More importantly, this allows me to avoid some of the partial year biases present in annual data as discussed by [Bernard et al. \(2017\)](#). I also aggregate export products from the 8-digit to the 6-digit HS level.¹⁴ I then match Chinese transaction-level data with US antidumping investigations against China, at the 6-digit HS level. It is the most disaggregated product category that is internationally comparable. Appendix table 3.7 presents means and standard deviations for the main variables of interest in my sample of product-quarter observations. On average, *targeted* products have higher export volumes and a larger number of exporters.

At the firm level, I aggregate the monthly customs data to the annual level as most firms do not export a given product to a given market in every month or quarter. This also allows me to avoid the seasonality and lumpiness typical of monthly data. By focusing on annual data, I abstract from these issues and related concerns with sticky prices.

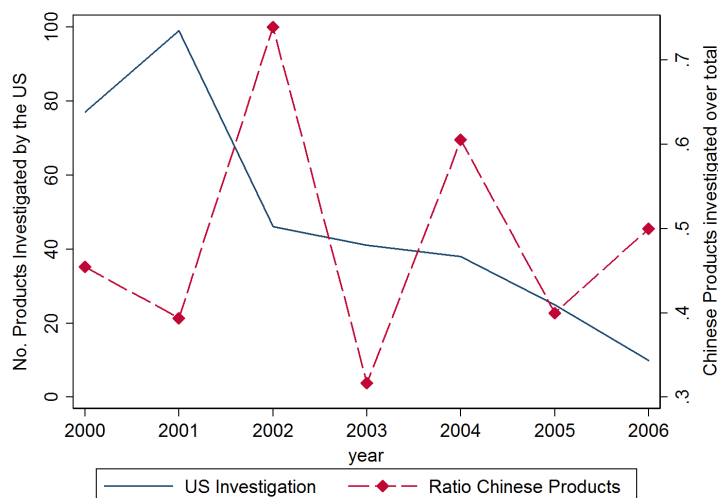


Figure 3.5: US antidumping investigations against China and the Rest of the World

Note: Elaboration based on the World Bank Global Antidumping Database from 2000 to 2006. The figure considers all antidumping investigations launched by the US against third-countries products. The share of Chinese products measured as the ratio between number of US investigations against Chinese products and the total number of US antidumping proceedings against third-countries imports.

There are a total of 47 US antidumping cases against China between 2000 and

¹⁴The HS codes underwent a major revision in 2002, and I adopt the 6-digit HS 1996 codes maintained by the World Customs Organization and use the conversion table from UN Comtrade to convert the HS 2002 codes into the HS 1996 codes, to ensure the consistency of the product categorization over time (2000-2006).

2006, which cover 147 unique products at the 6-digit HS level. Among the investigated products, 77 products ended up with final affirmative determinations, and antidumping duties were imposed on them. In addition, 49 products had affirmative preliminary ITC determinations but received negative final ITC determinations; 2 products were withdrawn before the final ITC determination. The rest of the 15 products either withdrew or were given negative decisions at the preliminary ITC stage. Figure 3.5 shows that the number of products is investigated for dumping by the US has decreased over time. However, the ratio of Chinese products which have been investigated is consistently high. Table 3.8, in the Appendix, lists the antidumping cases and related products that are covered in this paper. Figure 3.9, in the Appendix, illustrates the number of US antidumping initiations against China by year and the ratio of affirmative decisions.

The matched panel data from 2000 to 2006 contain 13,821 product-year-destination level observations and 1,213,138 firm-product-year-destination level observations. This level of disaggregation allows me to study within-firm adjustments at both the extensive and intensive margins of trade. I have 343 products at the 6-digit HS level in the matched data, with 77 of these products subject to antidumping duties.

3.5 Empirical Results

3.5.1 Product-level Trade Destruction

Before turning to the estimates of equation (3.3.1), I provide a visual summary of the time trend of export values for treated and control products at quarterly intervals spanning from four years prior to four years after the antidumping investigations. The vertical line marks the date of initiation of the investigations. This figure provides initial evidence that antidumping measures do affect the export values. First, there is an upward trend in the export values for both groups before the investigation. Secondly, it seems that before the investigation, the treatment and control groups do not exhibit differential time trend, indicating that the pre-existing trends are similar for both groups. Thirdly, antidumping measures have a clearly dampening effect on the export values of the products in the treatment group.

In table 3.1, I systematically investigate the extent to which antidumping measures destruct trade. All regressions reported in this table include quarter fixed effects, product fixed effects and investigation time fixed effects. Also, note that in this table and all following tables, the method of handling zeros in the estimation has been to use a functional form that adds 1 to all zeros before taking logarithms.

In column (1), the dependent variable is export participation in the US market. The coefficients ($\beta_{-9} \dots \beta_{-2}$) are close to zero and jointly insignificant, indicating that

the DID common trends assumption is satisfied. Moreover, it shows that antidumping measures are associated with a modest but meaningful reduction in the probability of a product being exported to the US. Specifically, I find that the antidumping-*targeted* products are approximately 10-16 percentage points less likely to be exported from the date of final antidumping duties is levied till the end of the sample.

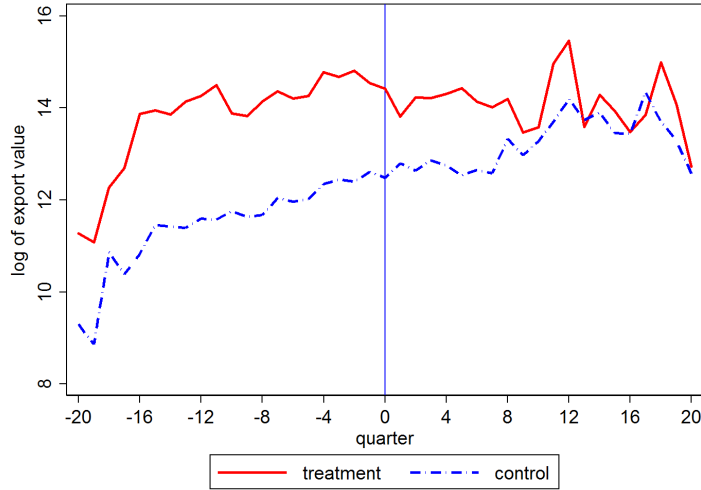


Figure 3.6: Time trend of product-level export values to the US

Column (2) shows a further extensive-margin estimation, in which I test the effect on the number of exporters in every product-destination-year cell. The number of firms exporting the *targeted* products during the investigation process is between 10% to 27% smaller than prior to the investigations.¹⁵ Then, the presence of antidumping measures averagely reduces the total number of firms serving the US market by about 30% after the investigation. Antidumping measures hence not only are associated with an adverse effect on the likelihood of products being exported but also result in a drastic decrease in the number of exporters.

Column (3) replaces the dependent variable by the log of export values. Again, The estimated coefficients of the treatment leads in this column are close to zero, showing little evidence of an anticipatory response for the products subject to antidumping duties. Nevertheless, a strong pattern emerges during the investigation: export values decline by 48% to 88%. They continue to decline untill the end of the sample period. Notably, this analysis encompasses the possibility that *targeted* products completely stop being exported to the US, as I include zero-export observations. Considering that

¹⁵The exact percentage difference in the predicted y when $D_{p,t} = 1$ versus when $D_{p,t} = 0$ is $\% \Delta y = 100 \times (e^{\beta} - 1)$.

Table 3.1: Trade destruction effect on the US at the product level

Years relative to investigation	(1) Participation dummy	(2) log of # of exporters	(3) log of export value	(4) log of export volume	(5) log of export price
9 or More Quarters Before	0.048 (0.063)	-0.125 (0.116)	-0.044 (0.728)	-0.103 (0.753)	-0.258* (0.154)
8 Quarters Prior	0.022 (0.054)	-0.060 (0.082)	0.054 (0.593)	0.087 (0.604)	-0.309* (0.160)
7 Quarters Prior	-0.008 (0.056)	-0.060 (0.069)	-0.044 (0.631)	-0.249 (0.663)	-0.191 (0.187)
6 Quarters Prior	0.016 (0.054)	0.025 (0.072)	0.165 (0.618)	0.013 (0.645)	-0.084 (0.187)
5 Quarters Prior	0.043 (0.055)	-0.001 (0.068)	0.431 (0.622)	0.307 (0.662)	-0.107 (0.162)
4 Quarters Prior	0.027 (0.055)	-0.025 (0.071)	0.386 (0.622)	0.072 (0.636)	0.020 (0.169)
3 Quarters Prior	0.028 (0.045)	-0.046 (0.049)	0.344 (0.501)	0.385 (0.542)	-0.127 (0.147)
2 Quarters Prior	0.016 (0.044)	0.040 (0.038)	0.284 (0.443)	0.237 (0.485)	0.009 (0.138)
Investigation Starts	0.007 (0.041)	-0.064 (0.048)	-0.027 (0.435)	-0.164 (0.469)	0.059 (0.127)
1 Quarter After	0.025 (0.049)	-0.094* (0.055)	0.008 (0.491)	0.048 (0.528)	-0.158 (0.177)
2 Quarters After	0.006 (0.055)	-0.157** (0.074)	-0.655 (0.578)	-0.724 (0.645)	-0.151 (0.147)
3 Quarters After	-0.078 (0.053)	-0.271*** (0.076)	-1.504** (0.603)	-1.658** (0.676)	-0.253 (0.170)
4 Quarters After	-0.094* (0.052)	-0.309*** (0.083)	-1.868*** (0.603)	-2.024*** (0.681)	-0.133 (0.182)
5 Quarters After	-0.127** (0.058)	-0.334*** (0.085)	-2.084*** (0.691)	-2.129*** (0.778)	-0.386** (0.189)
6 Quarters After	-0.148** (0.058)	-0.388*** (0.088)	-2.268*** (0.698)	-2.523*** (0.767)	-0.087 (0.158)
7 Quarters After	-0.137** (0.055)	-0.374*** (0.091)	-2.516*** (0.625)	-2.556*** (0.678)	-0.109 (0.247)
8 Quarters After	-0.164*** (0.058)	-0.355*** (0.103)	-2.545*** (0.695)	-2.843*** (0.772)	0.043 (0.225)
9 or More Quarters After	-0.098* (0.057)	-0.447*** (0.104)	-2.217*** (0.718)	-2.285*** (0.791)	-0.193 (0.176)
Quarter FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes	Yes
Observations	8,340	8,340	8,340	8,340	5,802
Adjusted R^2	0.568	0.950	0.764	0.731	0.717

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the antidumping duties imposed by the US on Chinese products often have exceeded 100% ad valorem, it is not surprising that *targeted* products are unable to continue to be exported. The subsequent column repeats these estimates using the log of export quantities as the dependent variable. The pattern of coefficients, in this case, is very similar to column (3), providing robust evidence that antidumping measures substantially destroy trade from China to the US.

Column (5) documents how antidumping measures affect export prices, proxied by the unit values at the 6-digit HS level. Export prices are remarkably stable over time, despite the antidumping measures that the products are subject to. However, this estimation may suffer from measurement error, as the unit values I calculate may be polluted by aggregation across firms. More importantly, it suggests the bulk of antidumping effect represents a quantity decrease.

Taken together, these estimates suggest that US antidumping measures considerably eliminate trade of the *targeted* products from China to the US. The *targeted* products less likely to be exported and there is a sharp decline in the number of exporters.

As highlighted in Bertrand et al. (2004), a multiple-period DID specification may suffer from serial correlation in the dependent variable (such as export values and quantities), which lead to over-rejection of the null hypothesis. One way to overcome the issue is to aggregate the data into two periods: pre- and post-intervention. I therefore adopt this remedy as a robustness check. Table 3.9 in the appendix shows the results with a single indicator that equals 1 following the initiation of the antidumping investigations. The estimates confirm that the imposition of US import restrictions negatively affects both the extensive and intensive margins of trade.

3.5.2 Product-level Trade Deflection

I have shown that antidumping measures have caused significant reductions in exports from China to the US. From a policy perspective, it is important to know whether the US use of antidumping measures against China imposes unintended consequences on unrestricted third markets, such as leading to an increase of the *targeted* products from China to alternative markets. My formal econometric estimates, presented in table 3.2, indicate no trade deflection. Perhaps more surprisingly, I find that the US antidumping restrictions result in Chinese exports neither surging nor falling to third markets.

Specifically, table 3.2 reports five specifications that use the export participation dummy to the RoW (column 1); the number of Chinese exporters serving the RoW (column 2); the export values, quantities and prices of the *targeted* products to the RoW (columns 3-5). Across specifications, we observe no pre-trending for any of the outcome variables, which lends credibility of the research design. Moreover, what is striking is that we do not detect any changes in the export of the *targeted* products from China to third markets, as in no case are these variables significant. That is, rather than any trade-reducing or trade-increasing effects, the US import constraints are associated with no effect on China's exports to alternative markets. To put it differently, trade policy changes in one market do not affect the evolution of trade

among *other* countries, where the policy does not change.

These findings seem to be inconsistent with existing empirical evidence (e.g. Bown and Crowley, 2007, 2010), which finds that antidumping measures spill over to other markets, regardless of whether these trade-reducing measures promote or distort trade in third markets. These conflicting results are attributed to the inclusion of $L_{pt}^{d,all}$ in the empirical specification. The current practice in the literature with a setting similar to mine, for instance, Crowley et al. (2018) and Lu et al. (2013), is to use specifications including product and year fixed effects only, without including $L_{pt}^{d,all}$. However, as I explained at length before, treatment occurs at only one point time in standard DID estimator, whereas in my setting, the investigations are staggered over time, $L_{pt}^{d,all}$ hence plays a role analogous to *Post* dummy that is common to both the treatment and control groups. To check whether a set of $L_{pt}^{d,all}$ is useful on the outcome variables, I also test their joint significances. The p-values are extremely small in all cases, showing that controlling for various investigation times is important to avoid bias, even year, product fixed effects are included. Had I not included $L_{pt}^{d,all}$, I would have obtained the results that antidumping measures have negative externalities on the trade that spread to third markets at the product level.¹⁶ That is, I would have wrongly concluded that these measures not only cause a considerable decline in the number of Chinese exporters serving alternative markets but also lead to a sizable reduction in export flows of the *targeted* products from China to the RoW.

In sum, I find that the imposition of US antidumping measures against China does not affect its exports to alternative markets. This finding seems to run counter to the argument that the change in US trade policy would push China's exports to other countries. To this end, my result questions the justification of the threat of China's export capacity to undermine and distort well-established world trade patterns.

In a robustness check, I again collapse the data into pre- and post-investigation periods to avoid the serial correlation problem in a multiple-period DID specifications. The results are presented in Table 3.10, which confirm that antidumping measures do not have externalities on aggregate trade to other markets.

¹⁶These results are available upon request.

Table 3.2: Trade deflection effect on the RoW at the product level

Years relative to investigation	(1) Participation dummy	(2) log of # of exporters	(3) log of export value	(4) log of export volume	(5) log of export price
9 or More Quarters Before	0.047 (0.045)	0.266* (0.137)	0.749 (0.610)	0.615 (0.617)	0.033 (0.066)
8 Quarters Prior	0.001 (0.017)	0.174** (0.082)	0.155 (0.259)	0.062 (0.270)	0.098 (0.076)
7 Quarters Prior	0.005 (0.017)	0.102 (0.070)	0.034 (0.228)	-0.033 (0.235)	0.079 (0.061)
6 Quarters Prior	-0.025* (0.015)	0.080 (0.067)	-0.231 (0.235)	-0.256 (0.235)	0.058 (0.052)
5 Quarters Prior	0.003 (0.016)	0.093 (0.067)	0.085 (0.217)	0.023 (0.223)	0.044 (0.054)
4 Quarters Prior	0.010 (0.017)	0.051 (0.069)	0.036 (0.211)	-0.005 (0.215)	0.046 (0.049)
3 Quarters Prior	-0.010 (0.020)	0.078 (0.052)	-0.052 (0.236)	-0.149 (0.284)	0.116 (0.100)
2 Quarters Prior	0.004 (0.014)	0.008 (0.043)	0.072 (0.140)	0.069 (0.150)	0.013 (0.048)
Investigation Starts	-0.008 (0.013)	0.096** (0.045)	-0.192 (0.175)	-0.141 (0.174)	-0.003 (0.038)
1 Quarter After	0.026* (0.016)	0.029 (0.057)	-0.013 (0.250)	0.031 (0.251)	-0.034 (0.055)
2 Quarters After	0.013 (0.014)	0.069 (0.058)	0.099 (0.239)	0.099 (0.237)	0.012 (0.046)
3 Quarters After	0.027 (0.019)	0.091 (0.064)	0.183 (0.244)	0.086 (0.241)	0.109** (0.047)
4 Quarters After	0.011 (0.020)	0.112* (0.060)	0.007 (0.281)	-0.067 (0.285)	0.057 (0.050)
5 Quarters After	-0.007 (0.025)	0.090 (0.056)	-0.304 (0.319)	-0.337 (0.332)	0.044 (0.054)
6 Quarters After	-0.006 (0.024)	0.029 (0.063)	-0.248 (0.309)	-0.211 (0.315)	-0.018 (0.059)
7 Quarters After	-0.047* (0.026)	0.022 (0.076)	-0.489 (0.328)	-0.531 (0.331)	0.076 (0.063)
8 Quarters After	-0.026 (0.021)	-0.012 (0.080)	-0.392 (0.288)	-0.418 (0.290)	0.046 (0.056)
9 or More Quarters After	-0.030* (0.017)	0.151* (0.084)	-0.219 (0.234)	-0.290 (0.240)	0.111* (0.065)
Year FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes	Yes
Observations	8340	8340	8340	8340	8019
Adjusted R^2	0.263	0.937	0.705	0.735	0.936

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5.3 Firm-level Trade Destruction

After documenting the effects of antidumping measures on trade at the product level, I now look at export adjustments within firms to reveal the possible channels driving the effects at the aggregate level. In this subsection, I investigate how these measures distort export patterns of Chinese firms in the US market. All the regressions reported in table 3.3 and all the following tables include year, firm-product and investigation time fixed effects.

The first column explores the impact of antidumping measures on export participation. Because of the firm-product fixed effects, the coefficients are identified out of firm-product pairs that either stopped exporting to the US following the investigation or sold in the US at least once before and after the investigation. The estimates indicate that the likelihood of participation in export activity to the US is about 2.7 to 6.8 percentage points lower among the *punished* firms after the investigations.

Table 3.3: Trade destruction effect on the US at the firm level

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
4 or More Years Before	-0.023 (0.039)	-0.134 (0.326)	-0.203 (0.249)	0.035 (0.041)
3 Years Before	-0.022 (0.020)	-0.217 (0.191)	-0.276* (0.154)	0.072 (0.055)
2 Years Before	-0.011 (0.011)	-0.107 (0.101)	-0.139 (0.087)	0.042 (0.028)
Investigation Starts	-0.011 (0.012)	-0.129 (0.119)	-0.083 (0.104)	0.046** (0.019)
1 Years After	-0.027** (0.014)	-0.213 (0.139)	-0.147 (0.113)	0.041** (0.019)
2 Years After	-0.046** (0.019)	-0.427** (0.197)	-0.357** (0.163)	0.068** (0.032)
3 Years After	-0.102*** (0.026)	-0.852*** (0.257)	-0.681*** (0.210)	0.077* (0.044)
4 or More Years After	-0.068*** (0.020)	-0.482*** (0.176)	-0.451*** (0.160)	0.117 (0.077)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	271,848	271,848	271,848	85,010
Adjusted R^2	0.092	0.244	0.263	0.863

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The following two columns present the results on how firm-level export flows to the US are affected by the US import restraints. First, both of them show that pre-

treatment trends do not differ between treatment and control groups, which is consistent with causal interpretations. Also, column (3) reveals that firms exporting the *targeted* products to the US experience a sizable decline in export volumes, approximately ranging from 20% to 40% four years after the investigation. These estimated effects include both a reduction in exports and a complete stop in trade. In other words, antidumping measures may not only result in a significant decrease in export flows among survivors but also lead firms to cease exporting. Taking into account the fact that the size of antidumping duties imposed on China has consistently exceeded 100%, it is entirely understandable that many firms are unable to continue to export to the US.

In column (5), I find that the presence of antidumping measures raises export prices by 5% to 10% for surviving firms. This result may look odd since firms do not have an incentive to change their price: since the US treats China as a non-market economy, the fair market value is determined from a surrogate country and the domestic price is irrelevant for the calculation of the dumping margin. However, this is not the entire story. Let me first stress that most survivors are assigned firm-specific antidumping duties, which are much lower than the industry-wide ones and are similar to those eligible to market economy companies, on average (see Figure 3.8 in the Appendix). Furthermore, antidumping duties are reviewed on an annual basis and are often revised. For Chinese firms that have ever been assigned individual rates, they have strong incentives to raise their prices in an attempt to maintain the low antidumping duties.¹⁷ Therefore, we observe price increases. In addition, when we compare the columns, it becomes clear that antidumping duties have a more significant impact on quantities than on prices.

Adding the investigation time dummies explicitly accounts for various treatment times that could potentially induce bias. Indeed, I find that these variables exert a jointly significant (at 1% level) impact on firm-level export patterns. Combining the findings in Table 3.1 and 3.3, we see that an increase in export costs (i.e., the imposition of antidumping duties) translates into lower exports through a decrease in export probability, and a decline in the number of exporters. It is also associated with reductions in export flows from survivors.

3.5.4 Firm-level Trade Deflection

Do US antidumping measures lead to the *punished* firms deflecting the *targeted* products from China to non-US markets? Table 3.4 presents the estimation results where the control group is the *unpunished* firms exporting *closely-related* products to

¹⁷That is, by raising the prices, the targeted firms' dumping margin falls, and hence the duty can fall.

the RoW. Overall, we conclude that Chinese firms which are exposed to the disruption of the US market do not deflect trade to other markets. On the contrary, I find that the US import constraints are associated with a chilling effect on the exports of the *punished* Chinese firms to alternative markets.

Specifically, column (1) concerns the firms' participation in export markets. We observe that the US-imposed antidumping duty on product p hurts the probability to export to the RoW by a *punished* firm. The estimated leads show that there are no pre-trends before the investigation. In the years after the investigation, an antidumping-*punished* firm is between 1.2 to 7 percentage points less likely to export the *targeted* products to the RoW.

Table 3.4: Trade deflection effect on the RoW at the firm level

Time relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
4 or More Years Before	-0.037 (0.033)	-0.314 (0.300)	-0.380 (0.259)	0.029 (0.052)
3 Years Before	-0.027 (0.017)	-0.243 (0.154)	-0.300** (0.137)	0.048** (0.023)
2 Years Before	-0.020** (0.009)	-0.164** (0.078)	-0.192** (0.078)	0.021 (0.016)
Investigation Starts	-0.006 (0.011)	-0.020 (0.105)	0.035 (0.106)	0.027** (0.011)
1 Year After	-0.012 (0.013)	-0.025 (0.123)	0.025 (0.118)	0.033* (0.017)
2 Years After	-0.041*** (0.014)	-0.267** (0.131)	-0.208* (0.120)	0.049** (0.021)
3 Years After	-0.075*** (0.015)	-0.482*** (0.129)	-0.391*** (0.122)	0.053* (0.030)
4 or More Years After	-0.067*** (0.023)	-0.309* (0.172)	-0.296* (0.179)	0.086** (0.039)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	762,448	762,448	762,448	258,886
Adjusted R^2	0.108	0.256	0.278	0.854

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Columns (2) and (3) report analogous results for firms' export values and quantities. These estimates show that firms restrain their export flows to alternative markets in which they have established trade relations. Specifically, in years 1 through 4 following the investigations, the export values of the *targeted* products to the RoW from

punished firms are reduced approximately by 33% - 37%. In column (4), I analyze the evolution of unit values to check whether prices have changed. The estimated coefficients are positive and significant for all years following the trade policy shock. Moreover, the price coefficients grow significantly over time, from 2.7% to 8.6%. Ultimately, antidumping shocks create negative spillovers and have harmful effects on the ability of the *punished* firms to export the *targeted* products to other destinations.

I interpret these findings as evidence of the impact of trade policy uncertainty on exporters. Recent contributions (Handley, 2014; Pierce and Schott, 2016; Handley and Limão, 2017) have shown that uncertainty over future trade policy has a real effect on international trade. The imposition of antidumping duties in the US is identified as a signal of rising trade policy uncertainty for the same product in other countries. That is, Chinese exporters are deterred by the US trade measures and may fear that tariff hikes for the same products would spread to other countries. Consequently, they choose to slow down their export expansion in these products to third markets. Therefore, we observe that surviving firms not only reduce shipments but also increase prices.

These findings are relevant to policy-makers. One implication is that the *punished* face an additional cost of antidumping, as they are not able to deflect trade and recoup the losses. This suggests that antidumping measures incur collateral damage and are even more detrimental to the *punished* firms in developing countries like China than previously assumed. Although the aggregate exports of the *targeted* products from China to the RoW were mostly unaffected, because of the entry of new exporters, they indeed exert a significant adverse effects on survivors.

3.5.5 Within-firm Product Switching

It is perfectly plausible that a trade restriction against one line of goods from a given exporter, f , could effect the exports of other goods from the same firm. That is, the breadth or extent of antidumping measures may go beyond the *targeted* products. In this section, I examine whether an antidumping measure against one product influences firms' export decisions for other products both to the US and the RoW. I first focus on how firms reshuffle their export activities across products to the US market.

Column 1 of table 3.5 displays the result of a basic linear probability specification. I find that the probability of exporting any *closely-related* products is about 2.3 to 8.0 percentage points lower among the *punished* firms. The dependent variables in columns (2) and (3) of are firms' export values and quantities of *closely-related* products to the US. Again, the inclusion of zeros implies that I compound both the surviving exporters and exiters, rather than pure intensive margin. The estimates show that the limitations on trade with the US negatively affect the trade flows of the *closely-related* products. Firms that were hit with these trade restraints reduce their exports

of unaffected products to the US by about 25% to 48%. These measures are also associated with price increase. In the years immediately following the investigation, the prices of the *closely-related* products from the *punished* firms go up by about 5% to 10%.

Table 3.5: Within-firm product switching to the US

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
4 or More Years Before	0.012 (0.023)	0.247 (0.194)	0.164 (0.146)	0.054* (0.031)
3 Years Before	0.005 (0.014)	0.084 (0.144)	0.038 (0.106)	0.036 (0.033)
2 Years Before	0.008 (0.010)	0.101 (0.094)	0.049 (0.079)	0.026 (0.028)
Investigation Starts	-0.023 (0.015)	-0.282* (0.145)	-0.244* (0.125)	0.050* (0.030)
1 Year After	-0.015 (0.011)	-0.165* (0.097)	-0.119 (0.077)	0.064*** (0.024)
2 Years After	-0.039** (0.017)	-0.431*** (0.153)	-0.382*** (0.131)	0.118*** (0.035)
3 Years After	-0.096*** (0.024)	-0.893*** (0.236)	-0.742*** (0.193)	0.092** (0.040)
4 or More Years After	-0.079*** (0.021)	-0.639*** (0.242)	-0.588*** (0.201)	0.077 (0.078)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	321,075	321,075	321,075	93,645
Adjusted R^2	0.062	0.201	0.211	0.851

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In sum, table 3.5 shows that the use of antidumping measures on one set of products against a firm reduces the trade flows of other unaffected products from the same firm to the initiation country. That is, antidumping measures generate a deterrent effect on firms, leading them to reduce shipments of the *closely-related* products to the US. The antidumping-*punished* firms may “learn” how to avoid dumping complaints by lowering the value or volume, and raising the price. In other words, antidumping measures generate negative spillovers on trade beyond the *targeted* products within firms. Moreover, combining the findings in table 3.3, we can conclude that an increase in the export cost of serving one market leads firms to downsize all their exports in that market. These results can also be interpreted in light of the literature on heterogeneous

firms and costs of trade (Melitz, 2003). Chinese exporters who may not recover the export costs required to service the US market reduce the exports both on the *targeted* and the *closely-related* products.

To complete the analysis of the effects of US antidumping measures on Chinese firms, I examine whether trade shifts to other products and other destinations of a *punished* firm. In column (1) of table 3.6, the dependent variable is a dummy variable that equals 1 if a firm exports an unaffected 6-digit HS product to the RoW in year t and 0 otherwise. The estimated coefficients for treatment leads are jointly significant at the conventional levels. This result suggests that the treatment and control groups do not have parallel trends before antidumping measures. Therefore, one might worry that they might differ in unobservable ways that invalidate the estimates.

Proceeding across specifications, in column (2) I redefine the dependent variable by a firm's export value of unaffected products to the RoW. The estimates show that the US antidumping measures have a dampening effect on the exports of *closely-related* products to alternative markets from a *punished* firm. The joint F-test for the presence of pre-existing trends is insignificant at the conventional level, suggesting there is no different trend prior to the investigations. The size of the estimated effect is substantial, exports to alternative markets decline by about 16% to 50% for firms that were subject to the US trade restrictions. Finally, I examine how firms' pricing behaviors are affected. I find that firms facing such policies raise prices of *closely-related* products in third-country markets in subsequent years.

These results merit at least two comments. First, the observed lower values and higher prices indicate a learning effect from the supply side. The more that firms are subject to such measures, the more likely that they slow down their export expansion to avoid further investigations. More importantly, combining the findings in table 3.4, we conclude that the imposition of an antidumping duty on one product within a firm, as a measure of rising trade policy uncertainty, negatively impacts a firm's export decision across products in *other* markets. These results demonstrate how the country-product specific nature of antidumping measures imposes externalities on non-targeted country-product pairs, widening our understanding of the breadth of such measures.

Summarizing the results presented in tables 3.5 and 3.6, I find that antidumping measures have detrimental effects that spread to other products and markets for the same *punished* firms. That is, the US import restrictions imposed on Chinese firms have resulted in reductions of the exports of the *closely-related* products across destinations. A logical implication of my findings is that growing export uncertainty reduce trade and policy instruments that increase uncertainty, such as antidumping, discourage trade.

Table 3.6: Within-firm product switching to the RoW

Time relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
4 or More Years Before	-0.010 (0.012)	0.021 (0.120)	-0.008 (0.111)	-0.019 (0.023)
3 Years Before	-0.017** (0.007)	-0.122* (0.071)	-0.137** (0.056)	-0.016 (0.015)
2 Years Before	-0.008 (0.005)	-0.033 (0.054)	-0.058 (0.044)	-0.011 (0.013)
Investigation Starts	-0.018** (0.008)	-0.168** (0.079)	-0.108 (0.070)	0.020** (0.010)
1 Year After	-0.017** (0.007)	-0.149** (0.067)	-0.078 (0.053)	0.041*** (0.013)
2 Years After	-0.048*** (0.009)	-0.410*** (0.090)	-0.324*** (0.071)	0.052*** (0.017)
3 Years After	-0.091*** (0.009)	-0.700*** (0.089)	-0.574*** (0.071)	0.021 (0.017)
4 or More Years After	-0.097*** (0.013)	-0.673*** (0.104)	-0.599*** (0.091)	0.041 (0.030)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	1,074,867	1,074,867	1,074,867	339,792
Adjusted R^2	0.078	0.208	0.219	0.846

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

3.5.6 Robustness Check

In order to check the sensitivity of my results, I experiment with an alternative estimation model. In particular, I use a specification with a dummy that equals 1 during the antidumping measures for the *punished* firms and another dummy that equals 1 during the antidumping measures for both the *punished* and *unpunished* firms at the firm-product level. The results are presented in tables 3.11 - 3.14 in the Appendix. These tables show large and statistically significant effects of antidumping measures for all outcome variables, consistent with the dynamic specifications. This suggests that the imposition of antidumping duties significantly restrain trade both from the extensive and intensive margins of trade across products and markets.

3.6 Conclusion

Using rich firm-level Chinese customs data over the period 2000-2006, I examine how antidumping measures affect product- and firm-level export dynamics. I find

strong evidence that the US antidumping restrictions reduce Chinese exports to the US both from the extensive and intensive margins. However, I do not find evidence that the imposition of such trade restrictions in the US have caused Chinese exports surging or declining to alternative markets. That is, a trade shock in one market does not affect the evolution of aggregate exports in another market, where the policy has not changed.

However, the overall impact of antidumping measures on trade at the product level hides a very rich set of within-firm adjustments. To uncover the channels through which exporters are affected, and improve our understanding of how such measures influence aggregate trade, I further explore their effects at the firm-product level. I document that Chinese firms that were hit with US antidumping measures decrease their exports of the *targeted* products not only to the US but also to alternative markets. These results imply that antidumping measures create negative externalities that go beyond the policy-imposing country. More importantly, antidumping measures are associated with a deterrent effect to other products and destinations within firms. That is, the exports of uninvestigated products both to the US and to alternative markets from the *punished* firms also experience a decline. On the policy front, the results presented here are worrisome. Because such measures generate a chilling effect on trade beyond the targeted products within firms, exporters in China face additional costs of antidumping. Finally, I find compelling evidence of a price increasing effect associated with antidumping measures within firms. This may suggest that firms increase their product quality in response to such negative trade shocks, though unit values may not directly reflect product quality.

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3.7 Appendix

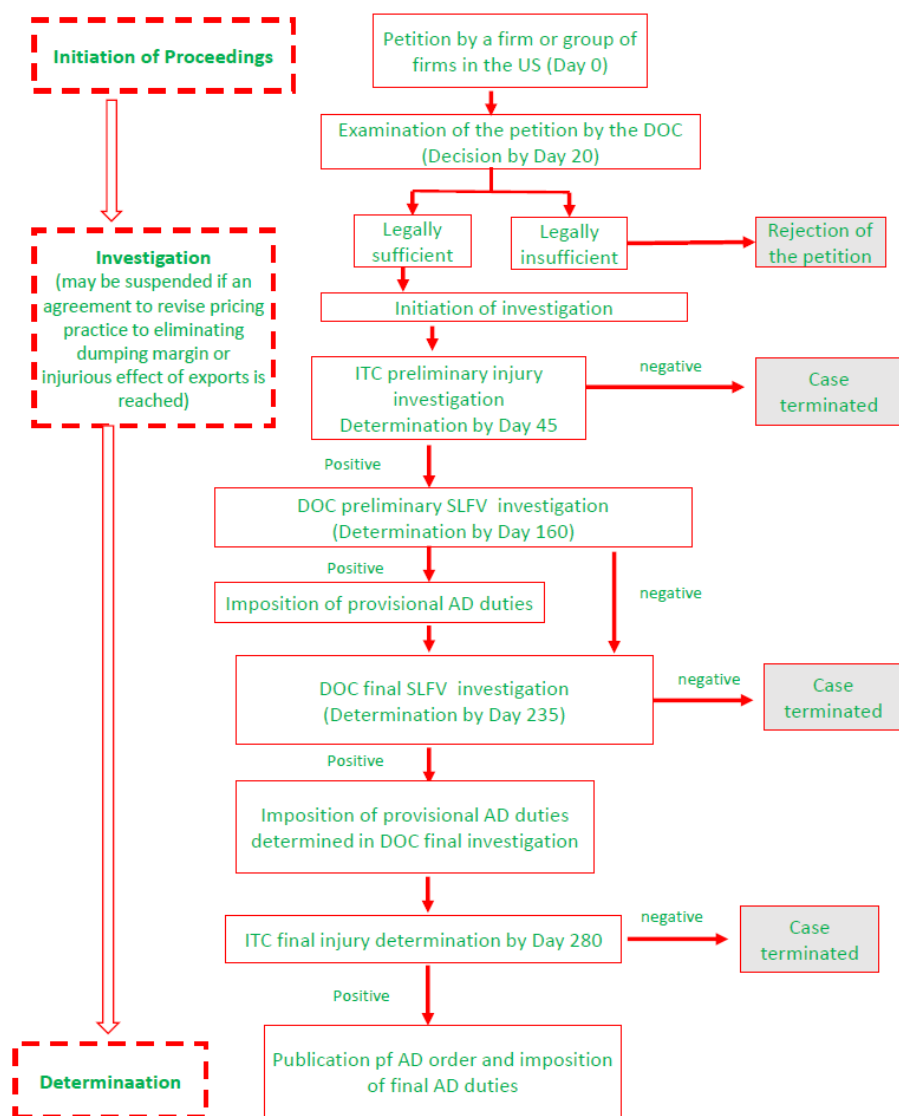


Figure 3.7: Flow Chart of US' Antidumping Proceedings

Table 3.7: Summary Statistics of Products

Variable	Before			After		
	(1)	(2)	(3)	(4)	(5)	(6)
	Closely-related	Targeted	<i>t</i> -Test	Closely-related	Targeted	<i>t</i> -Test
Log (total number of exporters)	0.505 (0.308)	0.591 (0.246)	-7.912***	0.500 (0.311)	0.423 (0.338)	7.189***
Log (total value of exports)	9.942 (2.342)	10.77 (2.303)	-8.552***	10.23 (2.504)	10.62 (2.704)	-4.613***
Log (total volumn of exports)	9.439 (3.005)	11.01 (2.659)	-13.690***	9.892 (3.135)	10.83 (3.054)	-9.469***

Note: Standard deviations are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

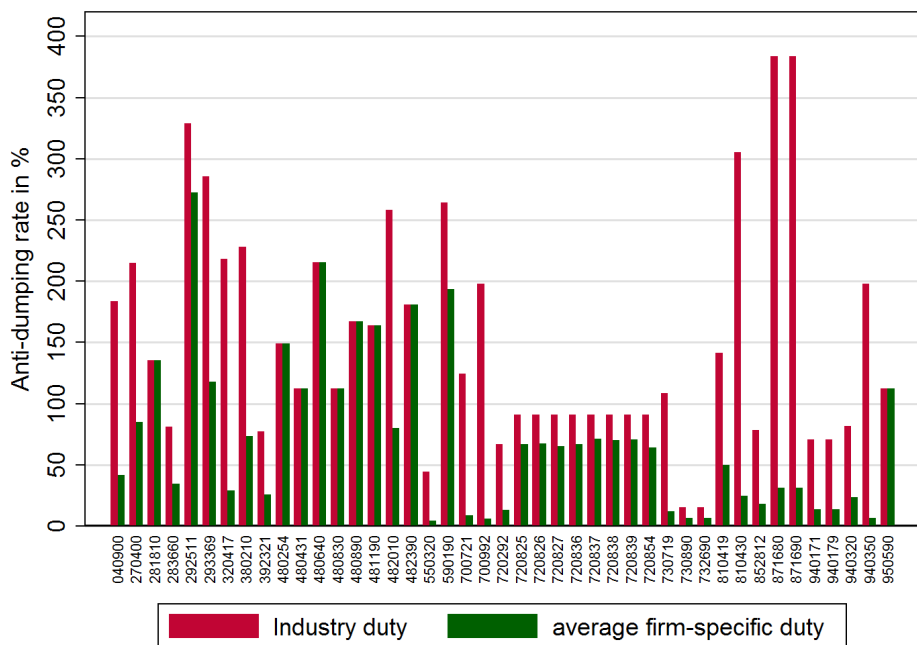


Figure 3.8: US antidumping measures against China: average duty per product

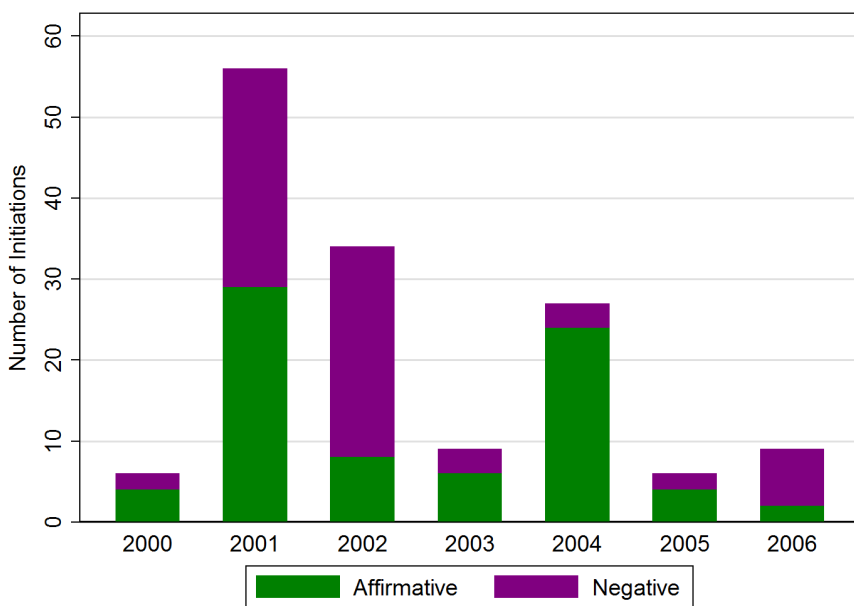


Figure 3.9: Antidumping initiations by year

Table 3.8: List of antidumping cases and treatment products

Case ID	Investigation Date	Treatment products	Preliminary Duty	Final Duty
USA-AD-874	07-Jul-2000	721420	59.98	133
USA-AD-893	06-Oct-2000	210690, 040900, 170290	183.8	183.8
USA-AD-899	22-Nov-2000	721119, 722511, 720827 721114, 720837, 720826 722540, 721250, 722519 721240, 722530, 720840 721090, 720854, 720853 722691, 720839, 720825 720838, 720890, 722619 720836, 720810, 722611	67.44	90.83
USA-AD-921	01-Mar-2001	481950, 481920	164.75	164.75
USA-AD-932	04-May-2001	940179, 940171	134.77	70.71
USA-AD-986	30-Nov-2001	720292	78.52	66.71
USA-AD-990	27-Feb-2002	730711	55.13	75.5
USA-AD-1010	08-May-2002	730890, 732690	32.73	15.61
USA-AD-1013	18-Jul-2002	292511	363.22	329.04
USA-AD-1014	13-Sep-2002	390530	97.86	7.86
USA-AD-1020	04-Oct-2002	283660	81.3	81.3
USA-AD-1021	06-Nov-2002	730719	146.41	111.36
USA-AD-1022	29-Nov-2002	281810	218.93	135.18
USA-AD-1034	13-May-2003	852812	78.45	78.45
USA-AD-1043	27-Jun-2003	392321	80.52	77.57
USA-AD-1046	30-Jun-2003	293213	31.33	136.86
USA-AD-1047	08-Jul-2003	940320, 940390	153.76	153.76
USA-AD-1058	10-Nov-2003	940350, 700992	198.08	198.08
USA-AD-1059	21-Nov-2003	871680, 871690	346.94	383.6
USA-AD-1060	28-Nov-2003	320417	370.06	217.94
USA-AD-1070a	23-Feb-2004	480439, 481890, 950590 480261, 482390	266.83	266.83
USA-AD-1070b	23-Feb-2004	480254, 480262, 480591 480890, 482050, 480431 480830, 480269, 480640 480230, 482090,	163.36	112.64
USA-AD-1071	09-Mar-2004	810419, 810430	177.62	141.49
USA-AD-1082	21-May-2004	293369	179.48	285.63
USA-AD-1091	06-Apr-2005	590190	264.09	264.09
USA-AD-1095	19-Sep-2005	482010, 481022, 481190	258.21	258.21
USA-AD-1103	29-Jun-2006	380210	228.11	228.11
USA-AD-1104	29-Jun-2006	550320	44.3	44.3

To demonstrate the robustness of my baseline estimates, I employ a second specification with a dummy turning to 1 during the antidumping measures for the *targeted* products (AD-Effects $_{pt}^{Treated,d}$) and another dummy turning to 1 during the antidumping measures for both *targeted* and *closely-related* products (AD-Effects $_{pt}^{All,d}$). Under my identification assumption, $\beta^{Treated}$ gives the average causal effects of the measures. The specification is as follows:

$$y_{pt}^d = \gamma_t^d + \delta_p^d + \beta^{Treated} \text{AD-Effects}_{pt}^{Treated,d} + \beta^{All} \text{AD-Effects}_{pt}^{All,d} + \varepsilon_{pt}^d. \quad (3.7.1)$$

Table 3.9: Trade destruction effect on the US at the product level

Years relative to investigation	(1) Participation dummy	(2) log of # of exporters	(3) log of export value	(4) log of export volume	(5) log of export price
AD-Effects Treated	-0.107*** (0.034)	-0.286*** (0.081)	-1.850*** (0.458)	-1.880*** (0.490)	-0.013 (0.104)
Quarter FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes	Yes
Observations	8,340	8,340	8,340	8,340	5,802
Adjusted R^2	0.559	0.949	0.756	0.722	0.718

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.10: Trade deflection effect on the RoW at the product level

Years relative to investigation	(1) Participation dummy	(2) log of # of exporters	(3) log of export value	(4) log of export volume	(5) log of export price
AD-Effects Treated	-0.027* (0.016)	-0.032 (0.071)	-0.417* (0.238)	-0.392 (0.243)	0.027 (0.050)
Quarter FE	Yes	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes	Yes
Observations	8,340	8,340	8,340	8,340	8,019
Adjusted R^2	0.242	0.933	0.694	0.724	0.934

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To examine the robustness of my findings, I adopt a second specification with a dummy turning to 1 during the antidumping measures for the *punished* firms (AD-Effects $_{fpt}^{Treated,d}$) and another dummy turning to 1 during the antidumping measures for both *punished* and *unpunished* firms (AD-Effects $_{fpt}^{All,d}$) at the firm-product level. Under my identification assumption, $\beta^{Treated}$ gives the average causal effects of the measures. The specification is as follows:

$$y_{fpt}^d = \gamma_t^d + \delta_{fp}^d + \beta^{Treated} \text{AD-Effects}_{fpt}^{Treated,d} + \beta^{All} \text{AD-Effects}_{fpt}^{All,d} + \varepsilon_{fpt}^d. \quad (3.7.2)$$

Table 3.11: Trade destruction effect on the US at the firm level

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
AD-Effects Treated	-0.035** (0.015)	-0.293** (0.141)	-0.195* (0.118)	0.042* (0.022)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	271,848	271,848	271,848	86,975
Adjusted R^2	0.090	0.243	0.261	0.864

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.12: Trade deflection effect on the RoW at the firm level

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
AD-Effects Treated	-0.016 (0.011)	-0.047 (0.106)	0.031 (0.101)	0.026* (0.015)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	762,448	762,448	762,448	268,649
Adjusted R^2	0.106	0.255	0.277	0.855

Standard errors clustered at the product level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.13: Within-firm product switching to the US

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
AD-Effects ^{Treated}	-0.043*** (0.011)	-0.455*** (0.107)	-0.369*** (0.085)	0.063** (0.028)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	321,075	321,075	321,075	93,645
Adjusted R^2	0.061	0.200	0.210	0.851

Standard errors clustered at the product level in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3.14: Within-firm product switching to the RoW

Years relative to investigation	(1) Participation dummy	(2) log of export value	(3) log of export volume	(4) log of export price
AD-Effects ^{Treated}	-0.033*** (0.006)	-0.289*** (0.070)	-0.199*** (0.055)	0.037*** (0.009)
Year FE	Yes	Yes	Yes	Yes
Firm-Product FE	Yes	Yes	Yes	Yes
Investigation Time FE	Yes	Yes	Yes	Yes
Observations	1,074,867	1,074,867	1,074,867	339,792
Adjusted R^2	0.076	0.207	0.217	0.846

Standard errors clustered at the product level in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 4

Firm-level Adjustments to Antidumping: Evidence from China

Abstract

In this paper, I examine how Chinese multi-product firms adjust their export behavior following the US antidumping measures. Using Chinese customs data from 2000 to 2006, I provide evidence that these trade-restricting measures induce firms to contract total sales by narrowing their product range and skewing sales further towards their best-performing products. More importantly, firms that were hit with antidumping measures experience more intense product churning. This finding suggests that Chinese firms might have the necessary flexibility to adjust their product mix to achieve an efficient allocation of resources, in response to the negative antidumping shocks.

4.1 Introduction

Over the past few decades, we have experienced an unprecedented reductions in tariffs and a substantial lowering of other trade barriers. These policy changes have enabled us to observe how trade liberalization affect the behavior of individual firms. While studies in this area are mainly concentrated on liberalization, comparatively little research investigates how temporary trade barriers, such as antidumping, affect firms' export behavior. How firms' export decision and value shipped are influenced? Do firms frequently adjust the product scope? In particular, the ways antidumping duties shape firms' behavior from the countries named in the measures remain poorly understood. These are significant omissions since antidumping measures are obstacles to trade which increase the export costs, and hence inevitably affect the export behavior of firms from the named countries. I seek to fill these gaps in this paper.

To this end, I estimate how US antidumping measures affect the adjustments of multi-product Chinese firms. In particular, I focus on the pattern of reallocation across

products within firms along the extensive margin of product adding and dropping, as well as along the intensive margin of changes in sales level and concentration among surviving products. The emphasis on multi-product firms is crucial because they dominate production and trade flows. Moreover, trade shocks that are exogenous to individual firms can be identified much more easily than at a higher level of aggregation, since reallocations are much easier to happen across product lines within firms than across firms. The analysis of how Chinese firms react sheds new light on the contribution of firms and products selection into the export market, to overall adjustment in firm-level exports.

The motivation for focusing on China is threefold. First, China has been the most targeted country of antidumping investigations initiated by the US. With a total of 549 investigations carried out by the US between 1995 and 2015, China has been the target of 127 cases. Secondly, the extent of the coverage of the US antidumping measures on China is considerable. Roughly 7 percent (\$35 billion) of Chinese exports to the US were subject to antidumping duties in 2015. Thirdly, the availability of firm-product level data over 2000-06 on both product entry and exit makes China a particularly relevant country for product churning analysis. Finally, the US antidumping measures against China have all taken the form of ad-valorem tariff, resulting in substantial duties for a narrow set of products. They are similar to traditional product-level import tariffs, but are only in force for five years. That is, antidumping measures can be considered temporary, whereas traditional tariffs have a more permanent nature. The temporariness of antidumping measures allows me to precisely estimate their consequences on firms, as they trigger much less industry dynamics, compared to more permanent trade liberalization.

I employ the difference-in-difference (DID) approach to identify the effects of US antidumping measures on firm-level export. Specifically, my identification strategy is based on the comparison of export decisions (e.g. whether or not to export, how much to export, *et cetera*) for firms that were subject to the US antidumping duties (referred to *punished* firms), compared to firms that were investigated but did not face any duties (referred to *investigated* firms). Notably, both treatment and control groups of firms have been involved in the antidumping investigations. This alleviates the concern that firms that were investigated for antidumping may have different characteristics to those that do not.

Several interesting findings emerge from my analysis. I first document that the imposition of the US antidumping measures weakly increases firms' likelihood of exporting. This supports the conclusion of hysteresis in export activity, i.e., once a firm has paid the sunk costs of exporting, it remains being an exporter (Baldwin, 1988, 1989; Roberts and Tybout, 1997; Bernard and Jensen, 2004). Moreover, I find that

firm-level exports decrease by 7.5 percent, as antidumping measures increase the variable export costs. I further decompose the export flows into extensive and intensive margins. Specifically, at the level of the firm, the extensive margin is the number of exported varieties, while the intensive margin is the average sales per product. Across firms, I find that the US antidumping duties reduce the range of exported varieties by 1.58 units, while their adverse effects on revenue per product are negligible. That is, most adjustment appears to come from the extensive margin. Within firms, I find that the trade-restricting measures induce the distribution of exports across products to be further skewed towards their best-performing products that survive.

A novel contribution of this paper is I consider within-firm reallocation effects. That is, I evaluate how product flows, measured by the counts of varieties added and dropped within firms, are affected by antidumping measures. I find that firms that were subject to these restrictions are more frequently adding and dropping products, relative to their counterparts. In particular, *punished* firms shed more products than they add, suggesting that antidumping shocks work as a force of creative destruction that leads to reshuffling across products. To put it differently, antidumping measures spur firms to rationalize their export behavior and this rationalization translates into more intense product churning. These results complement evidence in the prior empirical literature on the importance of firm and product churning in exporting (Baldwin and Gu, 2009; Arkolakis and Muendler, 2010). They also speak to the relevance of theoretical models of intra-firm product turnover (Feenstra and Ma, 2008; Eckel and Neary, 2010; Bernard et al., 2011; Mayer et al., 2014).

My paper is related to the growing literature on the internal allocation of resources within firms, in response to trade shocks. For example, Bernard et al. (2010), Goldberg et al. (2010a,b) and Iacovone and Javorcik (2010) show that the declines in trade costs induce multi-product firms to increase the product scope they exported and concentrate exports on their core products. In contrast to these research studies on trade liberalization, I examine how a temporary increase in trade costs affects within-firm product portfolio adjustments. The increased level of products adjustment found in this paper indicates that the reshuffling across products plays an important channel in the resource reallocation caused by changes in trade policy.

My work also sheds light on the impact of antidumping measures on targeted exporters. Lu et al. (2013) use transaction-level Chinese customs data and find that antidumping measures severely distort trade volume from China to the US. The substantial negative effect is mainly driven by the sharp decrease in the number of exporters. Chandra and Long (2013) use detailed Chinese firm-level data and reveal that the US antidumping measures decrease both the labor productivity and total factor productivity of the targeted Chinese firms. Brambilla et al. (2012) take one step beyond

standard firm-level analysis and document how individual household (i.e., producer) in Vietnam respond to the US antidumping duties. None of these papers, however, have systematically studied the overall effect of antidumping measures on the export scale and scope (i.e., intensive margin and *intra-firm* extensive margin) of firms as I do in this paper.

These findings are informative to policymakers, as they are crucial for designing appropriate policy interventions. Understanding the dynamics of introducing new varieties and shedding existing ones at the firm level constitutes the first step in understanding how exporters adjust their product portfolio to negative trade shocks.

The remainder of this article proceeds as follows. In Section 2 I describe the data and document some empirical regularities of multi-product firms in China. In Section 3 I present the estimation strategy, while in Section 4 I provide the empirical findings. Some concluding remarks follow in Section 5.

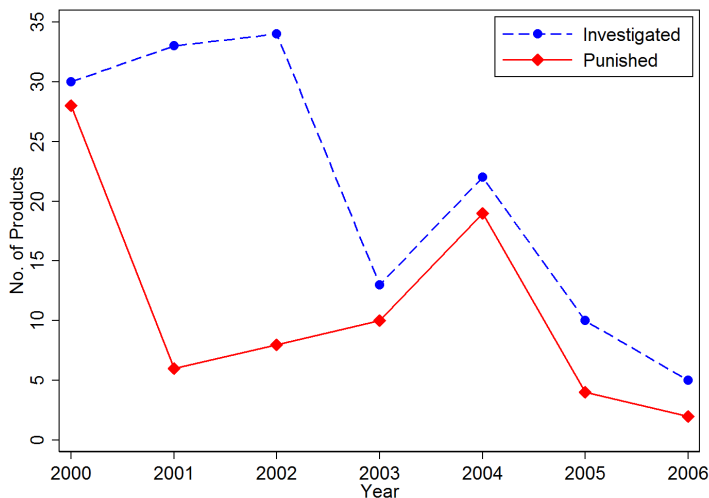
4.2 Data

My empirical analysis employs data from two sources: the Temporary Trade Barriers Database (Bown, 2015) and the Chinese customs data between 2000 and 2006.¹

The antidumping data come from the Temporary Trade Barriers Database of the World Bank. This database covers all the antidumping cases by all user countries in the world, with each investigation mapped to the targeted Harmonized System (HS) codes from 1980 to 2014. For the US, each antidumping case includes detailed product information (classified at the 10-digit HS level), the initiation date, the preliminary and final determination dates, decisions, along with the duty. I focus on all the antidumping proceedings carried out by the US against China from 2000 to 2006 and aggregate these products from the 10-digit to the 6-digit HS product level.

Between 2000 and 2006, 147 unique products at the 6-digit HS level from China were subject to the US antidumping investigations. Among them, 77 products were imposed antidumping duties (*punished* products). The rest of 70 products were investigated but ended up without any antidumping duties (*investigated* products). Figure 4.1 shows the annual counts of *investigated* and *punished* products. For instance, 28 out of 30 investigated products were subject to the antidumping duties in 2000. Moreover, there are spikes in certain years due mostly to macroeconomic factors such as China accession to WTO in 2001, and China removed export license in 2004. These phenomena reveal the need to control for macroeconomic factors in the empirical specification.

¹I thank Nankai University for providing the data.



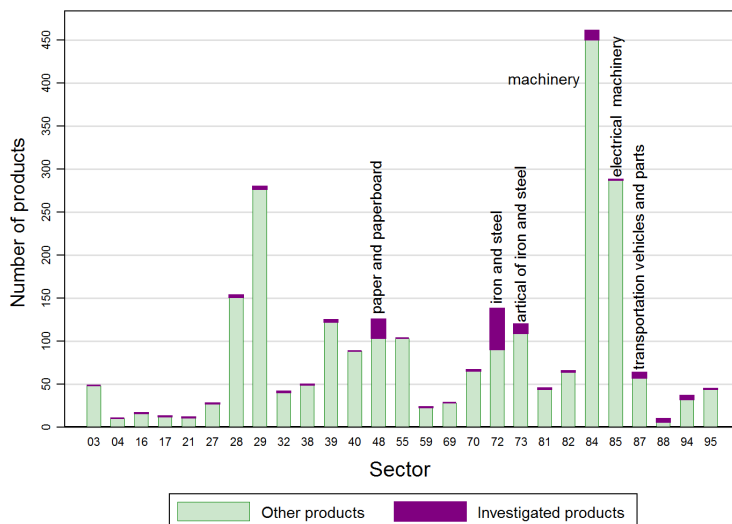
Source: Author's calculation based on the Global Antidumping Database (Bown, 2015).

Figure 4.1: Antidumping Investigations, by Years

Investigations cover a large variety of products in the manufacturing sector. Figure 4.2 documents the 2-digit HS sectors in China that were subject to US antidumping investigations between 2000 and 2006. It also gives the number of 6-digit HS products that were investigated by sector and over time. The most frequent targets of the antidumping investigation were products of “Iron and Steel” (Chapter 72) and “Articles of Iron and Steel” (Chapter 73). Other frequent targets have included products of “paper and paperboard” (Chapter 48), “machinery and stainless steel bearings” (Chapter 84 and 87).

The other component of the data that I use is the Chinese firms’ cross-border transaction-level data over the 2000-2006 period, obtained from China’s General Administration of Customs. These data report the monthly free-on-board value of import and export transactions by products in US dollars for all Chinese firms with the universal trading partners.² I work with annualized exports to avoid the seasonality and lumpiness typically displayed in monthly data. I also aggregate export products from the 8-digit to the 6-digit HS level, because China changed the 8-digit HS codes in 2002, and the concordance between the old and the new 8-digit HS codes (before and after 2002) is not available. Moreover, the HS codes underwent a major revision in 2002; I therefore adopt the 6-digit HS 1996 codes maintained by the World Customs Organization and use the conversion table from UN Comtrade to convert the HS 2002

²Specifically, the unit of observation is at the firm-product-destination-monthly level. The product is recorded at the Chinese 8-digit HS product level with a quantity, a value, and a unit value as the ratio of the shipment value to quantity. Quantity is measured by one of twelve different units of measurement (such as kilograms, square meters, *et cetera*).



Note: The purple bar represents the number of products that were subject to US antidumping investigations. The light green bar represents the number of products that were not affected by the investigations within each sector. Source: Author's calculation based on the Global Antidumping Database (Bown, 2015).

Figure 4.2: Antidumping Investigations, by Sectors

codes into the HS 1996 codes, to ensure the consistency of the product categorization over time (2000-2006). This is necessary to correctly assess the dynamics in terms of the number of products that a firm exports, to avoid misinterpretation of a product classification changes as an adjustment of firms' extensive product margin.

Some state-owned enterprises in China are pure export-import agents that do not engage in manufacturing but act exclusively as intermediaries between domestic producers (buyers) and foreign buyers (suppliers). Following standard practice in Ahn et al. (2011), I identify such wholesalers using keywords in firms' names and exclude them from the sample. I then match Chinese transaction-level data with the data of the US antidumping investigations against China, using the 6-digit HS product information. A total number of 22,826 Chinese exporters exporting 5,213 unique 6-digit HS products spanning 1,229 industries, covering 101 sectors to 231 destinations, experienced the US antidumping investigations. Among them, 15,418 firms were subject to the US antidumping duties. The rest of 7,409 firms were only involved in the investigations but were not imposed any antidumping duties.

Before proceeding to the empirical analysis, it is helpful to document some stylized facts about the firms that have experienced the US antidumping investigations. I first point out the relative importance of single- and multi-product exporters among them. Table 4.1 reports the share of each type of firm in the total number of firms, as well as their share in total export value in 2006. As indicated in the table, multi-product firms

dominate: they represent a majority of exporters (88 percent), and they account for a vast majority of shipments (98 percent). Multi-industry and multi-sector firms are similarly influential, responsible for 85 and 78 percent of firms but 96 and 92 percent of export, respectively. The final column reveals that the average multi-product firm produces 26.7 products, that the average multiple-industry firm’s manufactures in 17.8 industries, and that the average multiple-sector firm is present in 8.1 sectors. Compared to the results reported by Bernard et al. (2011), Chinese multi-product firms tend to span more industries and sectors, and they account for a larger share of export than multi-industry and multi-sector US firms.³ These facts seem to be consistent with China’s export-led growth policy, which has led to more product diversifications at the firm level.

Table 4.1: Prevalence of firms producing multiple products, industries and sectors in 2006

Type of firm	Percent of firms	Percent of export	Mean product, industries or sectors per firm
Single-product	12	2	1
Multiple-product	88	98	26.7
Multiple-industry	85	96	17.8
Multiple-sector	78	92	8.1

Note: The table categorizes firms according to whether they produce multiple products (6-digit HS product categories), industries (4-digit HS product categories), or sectors (2-digit HS product categories). Columns 1 and 2 summarize the distribution of firms and export, respectively. The final column reports the mean number of products, industries and sectors across firms exporting more than one of each.

Secondly, the model in Bernard et al. (2011) predicts that firms possess “core competencies”, so that the distribution of a firm’s export sales should be highly skewed towards its best performing product, i.e., a firm has its particular expertise. I also find the similar pattern that Chinese firms maintain a core competent product, with export inside the firm unevenly distributed across products. Table 4.2 reports the average share of firm export represented by each firm’s products, with products sorted from the largest to smallest. As shown in the table, the distribution of export across products is highly skewed, with the average share of firm exports attributable to the firm’s largest product, ranging from 87 percent for firms that export two products to 57 percent for firms that export 11-25 products. These results are also in line with what is reported by Bernard et al. (2011) for the US and Goldberg et al. (2010b) for India, and confirm the notion of “superstar” products, where a small club of products within a firm accounts for a vast majority of exports.

³Bernard et al. (2011) reports that 39 percent of US exporters are multi-product and account for 87 percent of total output. Among them, 28 percent and 10 percent of US firms span multiple industries and sectors and account for 81 percent and 66 percent of output, respectively.

Table 4.2: Mean Distribution of Within-firm Export Share, 2000 to 2006

Rank	Number of products produced by the firm							
	1	2	3	4-10	11-25	26-50	51-100	100+
1	1.000	0.869	0.802	0.697	0.561	0.429	0.299	0.183
2		0.130	0.159	0.182	0.188	0.171	0.137	0.094
3			0.038	0.069	0.092	0.097	0.086	0.065
4				0.015	0.021	0.031	0.037	0.033
5					0.002	0.005	0.010	0.012
6						0.001	0.002	0.005
7							0	0.002
8								0

Note: The columns indicate the number of products exported by the firm. Rows indicate the share of the products in firm export, in declining order of size. Each cell is the average across the relevant set of firm-product in the sample. Total number of observations: 2,169,228 (at the firm-product-yearly level).

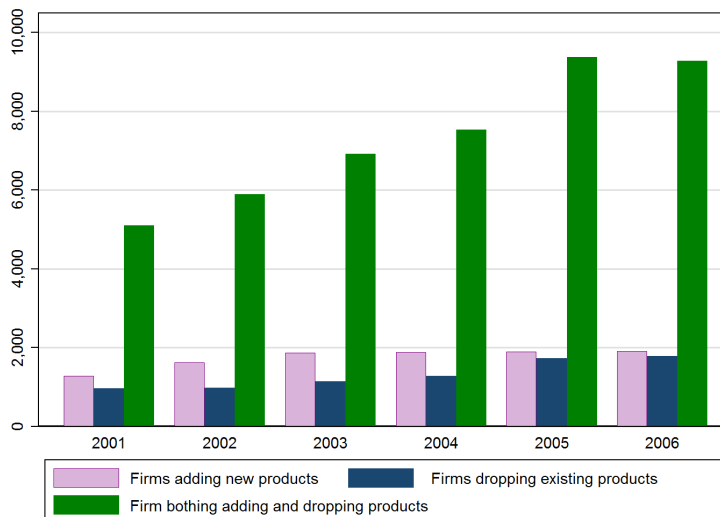
I next examine the importance of changes in firms' product margin over time. I begin by showing the average number of exported products per firm. The figures in Table 4.3 show remarkable stability in the average number of exported products at the firm level, though this average hides rich heterogeneity across firms. For instance, firms that were subject to the US antidumping duties export roughly 30 products, whereas firms that were investigated but did not face any antidumping duties export on average 10 products. But, the stable pattern still holds for both types of firms.

Table 4.3: The Number of Firms and Products

Year	# of exporters	# of products	The average number of varieties exported by		
			All firms	Punished firms	Investigated firms
2000	8,522	187,977	22.0	27.2	9.5
2001	10,035	231,262	23.0	29.0	8.4
2002	11,631	296,787	25.5	32.3	9.0
2003	13,565	350,072	25.8	32.5	9.7
2004	15,231	396,270	26.0	30.7	11.1
2005	15,605	382,380	24.5	30.7	11.0
2006	18,310	456,041	24.9	31.2	12.0

Source: Author's own calculations.

To shed light on the magnitude of product adding and dropping activities within firms, I divide firms into four mutually exclusive groups based on the manner in which they alter their product mix. Possible actions are: (1) *None* - the firm does not add or drop its products between years $t - 1$ and t , i.e., no change in the product mix; (2) *Drop* - the firm only drops products between years $t - 1$ and t ; (3) *Add* - the firm only adds products between years $t - 1$ and t ; and (4) *Both* - the firm both adds and drops products between years $t - 1$ and t , i.e., “churns” products.



Note: Exiting firms are included among those dropping export products.

Figure 4.3: Variety churning at the firm level

As depicted in Figure 4.3 and Table 4.3, many firms introduce new varieties, drop the existing ones or do both simultaneously. Each year about 1500 to 2000 firms either introduce a new export variety or drop an existing one. A much larger number, 4500 to 9000 firms simultaneously engage in both activities. In other words, there are intense churning activities at the product level, within firms.

The frequency and pervasiveness of product switching activities within firms are further reinforced by the findings in Table 4.4. As indicated in panel A, an average of 91 percent of surviving firms alter their mix of products every year, 12 percent by dropping at least one product, 15 percent by adding at least one product. In panel B of the table, I report export value weighted results, which reveal that a vast majority of manufacturing export (97.7 percent) is produced by firms that change their product mix every year. Firms both adding and dropping products account for the most significant share of export, at 87 percent. Overall, these stylized facts suggest that product additions and shedding are pervasive, frequent and widespread in China.

Table 4.4: Annual Product Adding and Dropping, average 2000-2006

Firm activity	All firms	Investigated firms	Punished firms
<i>Panel A. Percent of firms</i>			
None	9	11	8
Drop products only	12	13	11
Add products only	15	18	14
Both add and drop	64	57	67
<i>Panel B. Export value weighted percent of firms</i>			
None	2.3	5.5	1.6
Drop products only	3.3	5.4	2.9
Add products only	7.4	12.4	6.4
Both add and drop	87	76.7	89

Note: Panel A displays the annual average share of Chinese firms engaging in each type of product-changing activities from 2000 to 2006. Panel B provides a similar breakdown but weighting each firm by its export value. Products refer to the 6-digit HS categories. The four firm activities are mutually exclusive.

Figure 4.4 displays a simple histogram of the distribution of the number of products. It reveals that approximately 50 percent export less than six products, 25 percent export less than 14 products, with the rest of 25 percent exporting 15 products or more.

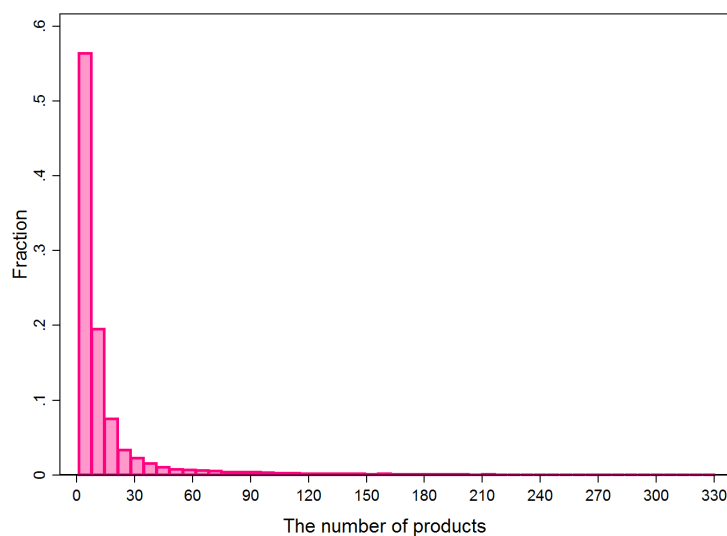


Figure 4.4: Histogram of the number of products

4.3 Empirical Framework

The objective of this paper is to shed light on how firms reshuffle their export activity across products in response to the US antidumping measures. To do so, I first estimate the consequences of these trade-restricting measures along the intensive margin of trade (i.e., export value by a firm), as well as several extensive margins, including the number of exported varieties and export participation at the firm level. The standard theoretical frameworks of heterogeneous-firm model predict that trade liberalization increases firm-level export. Following this rationale, rising in export costs is clearly detrimental for firm-level exports. However, their impact on the extensive margin of trade is ambiguous (i.e., firm-level export participation). Firms may reduce their probability of exporting to the destination imposing the antidumping measures, while raising their export participation to other markets. I then highlight the channels of within-firm product adjustments induced by these shocks. I pursue a difference-in-difference (DID) methodology which compares firms' outcomes before and during the imposition of the US antidumping measures.

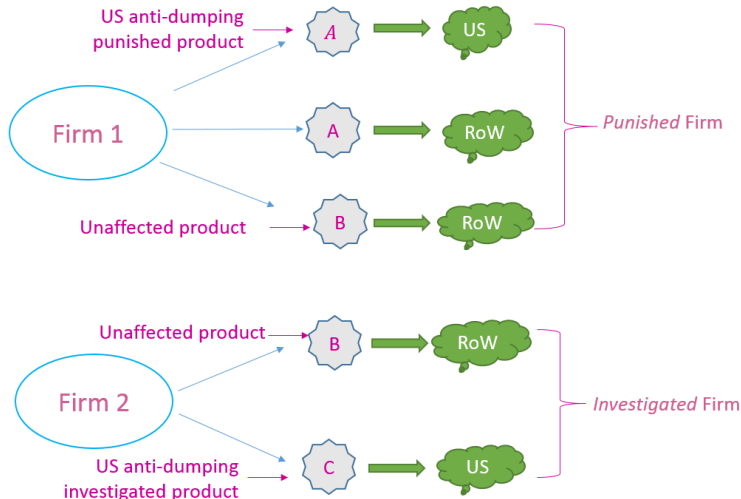


Figure 4.5: Product structure of multi-product firms

Figure 4.5 illustrates the multi-product firms in my analysis. The treatment group is defined as the *punished* firms that export multiple 6-digit HS products both to the US and the Rest of the World (RoW), with at least one of their product exporting to the US was subject to an US antidumping duty. By contrast, the control group consists of the *investigated* firms exporting a set of 6-digit products that did not face any antidumping duty, anywhere in the world. However, one of the product they export to the US was subject to an US antidumping investigation, but did not result in

any measure. By limiting the control group to firms whose investigations were ended without any measures, I control for the selection bias which arises if firms targeted by the investigations are different from those that do not. Consequently, both treatment and control groups are identical otherwise, and the concerns about sample selection is minimized. More importantly, I control for the investigation effect as both groups are all investigated. The previous literature (Staiger and Wolak, 1994; Besedeš and Prusa, 2017) have shown that investigation can already negatively impact trade, and therefore my estimate is likely to yield a smaller effect than the true one. Specifically, I examine the export patterns of the *punished* versus the *investigated* firms by the following specification

$$y_{ft} = \alpha_f + \alpha_t + \beta AD\text{-}Effect_{ft} + \varepsilon_{ft}, \quad (4.3.1)$$

where the subscripts f and t denote respectively for firm and year.

The dependent variables are described as follows. I first define a dummy variable that equals 1 if firm f has positive trade flows in year t and 0 otherwise, to capture the firm-level export participation.⁴ This allows me to identify whether the imposition of the US antidumping measures affects firms' likelihood of exporting. I next use the log of real export turnover of firm f in year t as the dependent variable to measure how increases export costs impact export flows.⁵ I further decompose firms' value shipped into the number of exported varieties and the average sales per products, to quantify the contribution of within-firm product extensive margin to the overall change in the value of firms' exports.

Moreover, I use "entropy" to measure of product diversification. The "entropy" is defined as $\sum_k s_{fkt} \ln(s_{fkt})$, where s_{fkt} represents the share of a firm's export value accounted for the 6-digit HS product k . It captures the extent to which a firm's export is skewed toward its largest rather than its smallest products. I also compute the "entropy" of all other products within a firm (excluding the *punished* ones), $\sum_{k \neq j} s_{fkt} \ln(s_{fkt})$, where j indicates the *punished* products. The "entropy" with the exclusion the *punished* products allows me to capture the general skewness of the entire product sales distribution that is not affected by the measures.

Further, I assess the relative importance of product switching as a new dimension of resource reallocation that complements firm entry or exit. To do so, I introduce the following two variables. I define add_{ft} as the sum of the new export varieties of firm f introduced in year t which did not export in year $t - 1$. Likewise, I define $drop_{ft}$ as the sum of the varieties of firm f ceasing to be exported in year t that were exported in year $t - 1$. These two variables not only measure true product turnover, that is, the

⁴If it equals to 0, it means that a firm has no export in year t .

⁵I only include positive values.

count of products exiting and entering within firms, but also capture the role of firms' product margin in adjustment to trade shocks.

The $AD\text{-}Effect_{ft}$ is a dummy that takes a value of 0 for the years before the US antidumping measures and 1 in the years during the antidumping measures but only for the *punished* firms. Firm fixed effects, α_f , capture the all time-invariant unobservable characteristics that might affect firms' export performance. Year fixed effects, α_t , control for common macro shocks and business cycle effects that may affect all firms; and ε_{ft} is a stochastic error. I cluster the standard error at the firm-level to control for the serial correlation within a firm across years.

Each firm in the treatment group is assigned a date of treatment and an ad-valorem duty, which comes from the results of the antidumping measures associated with the product it exports.⁶ If a firm has more than one product that is subject to an antidumping duty, the treatment date is the one related to the product that accounts for the highest share of its shipment.⁷

4.4 Empirical Results

Before turning to the estimates of Equation (4.3.1), Figure 4.6 provides the suggestive evidence that antidumping measures affect the product turnover. Specifically, it shows the time path of the number of exported products for *punished* and *investigated* firms at yearly intervals spanning from six years prior to six years after the investigations. The vertical line marks the date of imposition of preliminary duties. While there is a drop in the product scope for *punished* firms after the measures, there is no visible change in the trend of product scope for *investigated* firms.

Table 4.5 reports the results of how changes in trade policy in the US affect the export behavior of Chinese firms. In column (1), I find that the imposition of antidumping measures on firms marginally increases their likelihood of exporting by 0.5 percentage points. This result may seem odd, but it can be explained by hysteresis in export activity: exporters who have already paid the fixed entry costs to export may "hang in" there via exploring new trading relationships, since the duration of the antidumping measures is in principle limited to 5 years. Moreover, the previous finding (Lu et al., 2013) that antidumping measures have resulted in a sharp decline in the number of exporters should be interpreted as the firm-product-destination level

⁶The treatment year is defined as the year in which the preliminary antidumping duties were imposed for the *punished* firms.

⁷However, it is possible that firms may learn to adjust their export activities following their first experience of the antidumping measure. I therefore define the treatment year as the preliminary decision date of the earliest antidumping measure to the firm as a robustness check. The results are quantitatively similar.

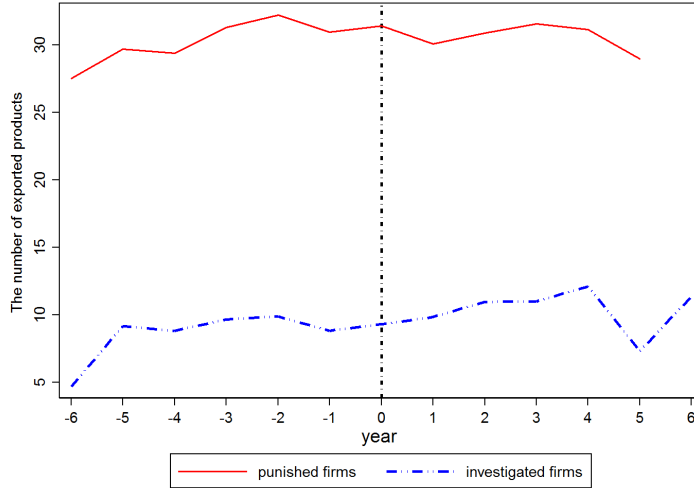


Figure 4.6: Time trend of number of exported products

reduction, not at the firm level. Firms that were hit with the antidumping shocks may stop exporting the specific-product to the policy-imposing market (e.g. US), but these constraints do not restrict their overall ability to export.

I now turn to analyze whether the US antidumping measures have depressed Chinese firms' export flows. From column (2) we note that the imposition of such duties results in a sizable decrease in export turnover of about 7.5 percent on average.⁸ Moreover, these measures are associated with a negative effect on firms' product range, as is shown in column (3). Specifically, Chinese firms that were exposed to the US trade restrictions reduce their number of the exported products by almost 1.6 units.⁹ There is also a decline in average exports per product within firms, though is not significant. The lack of relationship between export product sales and antidumping measures suggest that the trade destruction effect on firms' export is almost entirely driven by the extensive margin: the decrease in the number of exported products. Increasing trade costs translate into lower export through a decline in the number of exported varieties, however, it does not affect average shipment per product within a firm.

I next consider how firms adjust their distribution of sales across products to the antidumping shocks, using "entropy". Specifically, column (5) reveals that firms that were faced with the US antidumping measures exhibit rises in entropy. This conclusion

⁸The exact percentage difference in the predicted y when $D_{p,t} = 1$ versus when $D_{p,t} = 0$ is $\% \Delta y = 100 \times (e^{\beta} - 1)$.

⁹Taking the log of this variable yields similar result, the *punished* firms have experienced a sizable 4.6 percent reduction in product range after the shocks ($t = -3.62$), which contribute to $0.046/0.075 = 61.3$ percent of the firms' export value losses.

is further bolstered by the results in column (6), where I use the entropy measurements with the exclusion of *punished* products. In particular, rather than a marginally significant increase in entropy, firms that were subject to the US antidumping measures exhibit noticeably, 4.3 percent rises. These findings indicate that the export sales of *punished* firms are further concentrated toward the largest, rather than the smallest products that are not targeted by the trade-restricting measures after the shocks.

Overall, these results provide show that the US antidumping measures induce Chinese firms to contract total export sales by narrowing their product range and skewing sales further towards the top infra-marginal products. However, the extensive margin of trade dominates.

I then discuss how product flows, i.e., the count of products entering and exiting the market within firms, are affected by these measures. This analysis links how increases in export costs contribute to within-firm product selection into the export markets. Prior to estimating their impact, I tabulate in the appendix (Table 4.6) benchmark estimates of the firm-level relationship between product creation, destruction and product scope. I find that the product-flow measures capture a substantial share of variations in the product mix within firms: 1 percentage point of product creations increases the product scope by almost 10 percent, and 1 percentage point of product destruction reduces the product range by 4.3 percent.

Columns (7) and (8) present the estimates for product adding and dropping within firms. The estimated results show that Chinese firms that were subject to the US antidumping measures experience more intense product churning activities. In particular, they on average add roughly 0.8 products more as well as drop 2.5 varieties more. The combined effect of the extensive margins, seen by adding the coefficients across columns (7)-(8) almost complete explains the firm-level variation in product scope. More importantly, firms drop more products than they add, suggesting that firms rationalize their shedding activities as antidumping measures are product-specific shocks. This finding might also reflect that Chinese firms have the flexibility to reshuffle their product mix in response to the policy changes.

Summing up Table 4.5, I find that the US antidumping measures have a considerable negative impact on firm-level export, which is mostly caused by the decrease in the number of exported products, while it is uncorrelated to the average export per firm. Further, the adverse antidumping shocks induce Chinese firms to skew the export sales towards their best performing product. More importantly, the discontinuation of product lines contributes to the net product margin, suggesting that “creative destruction” along the product dimension. That is, firms restrict their product range in response to the negative trade shocks; product destruction outweighs product addition along the product extensive margin within firms. To this end, we connect the changes in firms’

product mix to changes in trade policy.

4.5 Conclusion

This paper adds to the literature on trade policy and how that affects multi-product firms from the perspective of a large developing country. I show that the US antidumping measures reduce the export flows of Chinese firms by 7.5 percent. Decomposing the firm level exports into the extensive and intensive margins, I find that firms adjust to a rise in trade costs via narrowing the portfolio of exported products (*intra-firm* extensive margin). However, there is no impact on the average sales per product within a firm. That is, the extensive margin dominates. I also find that multi-product firms tend to further skew their sales toward their best-performing products. These results imply that rising in variable trade costs (i.e., increase in tariff) combined with the presence of core competence pattern leads to an adjustment in the range of products exported at the firm level.

I then provide evidence that variety churning within the firms is another important margin of adjustment taking place, in response to the antidumping shocks. I document that *punished* firms experience more intense product churning, as they speed up the process of both the introduction and discontinuation of export products, relative to their counterparts. My analysis therefore highlights the role of selection across products within firms matters for transmission of external shocks. A deeper understanding of the role of the extensive and intensive margins of trade can help, for example, to shed light on mechanisms through which trade costs affect trade flows and the channels of antidumping measures affect the allocation of resources within firms.

These results are essential in understanding the effect of antidumping measures on exporters. Fruitful avenues for future research include seeing what types of products firms tend to add and drop. It is the first step in understanding whether antidumping measures from the US induce Chinese firms to adjust their product quality. It is also important to know how exporters adjust their export activity differently across markets, as the product-level antidumping shock is market-specific which increases the export cost to the policy-implementing country. This exercise will inform how a cost shock in one market impacts firms' product portfolio in other markets, i.e., how firms' export behavior are linked across markets, which will deliver significant implications for the welfare effects of the trade policy changes.

Table 4.5: The effect of the US antidumping measures on Chinese firms

	(1) Export dummy	(2) Export value	(3) Number of products	(4) Average sales per product	(5) Entropy	(6) Unpunished entropy	(7) Sum of added products	(8) Sum of dropped products
AD-Effect	0.005* (0.003)	-0.075*** (0.023)	-1.577*** (0.454)	-0.029 (0.019)	0.025* (0.013)	0.043*** (0.013)	0.804*** (0.290)	2.514*** (0.340)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	94311	91937	94311	91937	91937	88637	94311	94311
Adjusted R^2	0.139	0.691	0.738	0.752	0.737	0.743	0.398	0.413

Standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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4.6 Appendix

Table 4.6: Relationship between product adding and dropping and product scope within firms

	Dependent Variable: Log of the number of exported varieties		
	(1)	(2)	(3)
Product creation	0.976*** (0.012)		
Product destruction	-0.043*** (0.004)		
Gross churning: creation+destruction		-0.042*** (0.004)	
Net churning: creation-destruction			0.047*** (0.005)
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	91937	91937	91937
Adjusted R^2	0.815	0.773	0.780

Note: Product creation as the number of new varieties introduced in year t divided by the total number of varieties exported by firm f in year t . Likewise, product destruction as the number of products ceasing to be exported in year t divided by the total number of varieties exported by firm f in year t . I refer to the sum of the two as gross churning and to the difference as net churning.

Standard errors clustered at the firm level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$